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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 67
1957

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RICHARD A. LAUBENGAYER, Editor
Wabash College
Crawfordsville, Indiana

•

Spring Meeting
May 10-11
Turkey Run State Park

Fall Meeting
October 17-19, 1957
DEPAUW UNIVERSITY

Published at Indianapolis, Indiana
1958

1. The permanent address of the Academy is the Indiana State Library.

2. **Instructions for Authors** appear at end of this volume, p. 324.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

John Shepard Wright Memorial Library of the Indiana Academy of Science.
c/o Indiana State Library
Indianapolis 4, Indiana.

4. **Proceedings** may be purchased through the State Library at $3.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and By-Laws reprinted from v. 62 and the Membership List reprinted from v. 61, are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives anl friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Biology Department, Wabash College, Crawfordsville, Ind.

Papers published in the Proceedings of the Indiana Academy of Science are abstracted or indexed in appropriate services listed here:

Annotated Bibliography of Economic Geology
Bibliography of Agriculture
Bibliography of North American Geology
Biological Abstracts
Chemical Abstracts
Chemisches Zentralblatt
Current Geographical Publications
Geological Abstracts
Mathematics Reviews
Metallurgical Abstracts
Psychological Abstracts
Review of Applied Entomology
Zoological Record

TABLE OF CONTENTS

Page
Officers and Committees for 1957 6
Minutes of the Spring Meeting 9
Minutes of the Executive Committee 10
Minutes of the General Session 17
Complete Membership of the Year 1957 19
Junior Academy of Science 49
Necrology 56
Presidential Address—WILLIS H. JOHNSON 73

Anthropology

Abstracts of papers not published in full 90
F. X. GROLLIG—Pottery ornaments from Rio Tapajós, Brazil 92
R. B. JOHNSTON—The findings after two years of work at Serpent Mounds Site, Rice Lake, Ontario 96

Bacteriology

Abstracts of papers not published in full 98

Botany

Abstracts of papers not published in full 101
A. T. GUARD and S. N. POSTLETHWAIT—Relation of the formation of annual rings to multiple flushes of growth in several species of Quercus 104
R. P. DANIELS and C. L. PORTER—A basidiomycete which sporuluates in artificial culture 107

Chemistry

Abstracts of papers not published in full 109
D. L. MCMASTERS and W. B. S3œ(($—High-speed calculation of least-squares best consecutive formation constants of metal-ion complexes using an electronic computer 111
D. L. MCMASTERS and W. B. SCHAAP—High-speed calculation of least-squares best half-wave potentials and slopes of polarographic waves using an electronic computer 117
A. MOFFAT and H. HUNT—A method of calculating the heats of combustion of organic compounds 122
R. F. BABCOCK and R. B. FISCHER—Aging of reagent solutions in precipitation processes 128

Entomology

Abstracts of papers not published in full 135
C. A. SMITH, JR.—*Drosophilidae* found in tomato fields in Indiana . . . 138
D. L. SCHUDER—Some new insect pests of trees and shrubs in Indiana 145

Page

J. V. OSMUN—Insects and other arthropods of economic importance in Indiana in 1957 150

C. A. MULLIN—Location of larvae of the European corn borer, *Pyrausta nubilalis* (Hbn.), in dent corn 155

B. L. MONTGOMERY—The anthophilous insects of Indiana. 2. A preliminary list of the diptera collected from blossoms 160

F. N. YOUNG—A large aggregation of larval millipeds, *Zinaria butleri* (McNeill), in Brown County, Indiana 171

G. E. LEHKER—The ten most important plant feeding pests in Indiana 173

Geology and Geography (including Soil Science)

Abstracts of papers not published in full 175

T. G. PERRY—Effect of geologic processes on economic resources of late paleozoic rocks of Indiana 178

S. S. VISHER—Indiana's probable climate during the glacial period 183

C. L. BIEBER—Fossil cephalopods of Mississippian Age, Central Putnam County, Indiana 185

JOHN FRASER HUNT—Age pyramids for Indiana's counties and larger cities 187

W. N. MELHORN—Revision of Mississippian-Devonian boundary in White and Benton Counties, Indiana 194

JOHN FRASER HUNT and P. P. COSTAS—Interurban distances in Indiana: an evaluation of techniques 199

H. H. MURRAY—Trangressions and regressions of early allegheny (Pennsylvanian) seas in Indiana 205

YI-FU TUAN—The misleading antithesis of penckian and davisian concepts of slope retreat in waning development 212

L. GUERNSEY—Reclamation of strip-mined lands in Vigo County, Indiana 215

R. W. LOUNSBURY and R. L. SCHUSTER—Preliminary report on the petrology of Southampton Island, Northwest Territory 225

Soil Science (Affiliate)

Abstracts of papers not published in full 232

S. R. WILKINSON, W. G. DUNCAN and A. J. OHLROGGE—The influence of radioactive fallout on agronomic field experimentation with radioisotopes 234

H. MOTTO and J. L. WHITE—Specific surface and reaction rate of calcitic limestone in neutralizing soil acidity 237

History of Science

Abstract of paper not published in full 243

D. DENUYL—Forests of the lower Wabash Bottomlands during the period 1870-1890 244

S. S. VISHER—Aspects of the wiser use of Indiana's soils 249

W. J. TINKLE—The extent of effectiveness of natural selection 251

Page
H. H. MICHAUD—History of the early development of game regulations in Indiana 256
R. E. GIRTON—The teaching of plant physiology at Purdue in the nineteenth century 260
L. A. SCHAAL—Early weather records in Indiana 265
J. E. CANRIGHT—History of Paleobotany in Indiana 268

Mathematics

Abstracts of papers not published in full 274

Physics

Abstracts of papers not published in full 277
C. S. MORRIS—Physics research in a small institution 282

Plant Taxonomy

Abstracts of papers not published in full 286
L. J. KING—On the origin of the term "weed" 287
C. A. MARKLE—Contributions to the flora of Wayne County, III 290
J. S. PELTON—Evidence of introgressive hybridization and mutation in certain Colorado populations of Aquilegia 292

Psychology

Abstracts of papers not published in full 297

Zoology

Abstracts of papers not published in full 300
C. F. LYTLE—The records of freshwater medusae in Indiana 304
F. J. ZELLER—The effect of stilbestrol on the ovary of the immature white leghorn pullet 309
R. E. SMITH, W. R. BRENEMAN and M. CORMACK—The action of lithosperm in mice 312
J. B. COPE, R. E. MUMFORD and N. WILSON—Some observations on a summer colony of *Myotis lucifugus* 316
C. J. GOODNIGHT—Two representatives of a tropical suborder of *Opilionids* (Arachnida) found in Indiana 322

Appendix

Instructions for contributors 324
Index to Volume 67 326

Officers and Committees

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May 20, 1957

SPRING MEETING

Turkey Run State Park

May 10-11, 1957

4:30 p.m.

Treasurer Frank Welcher gave no formal report except as continued from the last fall meeting. An estimated $1,500 has been received since dues statements were mailed out. About 25 resignations were reported, most of which were from out of state.

Editor R. A. Laubengayer gave a progress report in which he stated that galley proofs were going out in June or July. Three per cent has been taken out of the state appropriation for the publication of the Proceedings, but it may be returned.

Librarian Nellie M. Coats reported that the Lilly Endowment, Inc. has presented $6,400 to the library to fill files and catch up with binding. An exhibit case will be obtained and installed. The secretary was instructed to thank the Lilly Endowment, Inc. as an expression of thanks from the business session.

Press Secretary James Clark gave a general report.

There was no formal report from Program Chairman T. G. Yuncker.

Membership Chairman H. R. Youse gave a report. Dr. Yuncker suggested a faimly membership for husband and wife. A discussion followed.

Invitations Committee chairman Winona Welch said that the committee needed an invitation for the fall meeting in 1958.

Under new business, a check was received for $50 from a benefactor in California. There was a report by the president on the Special Committee on Undergraduate Research in Biology. Dr. Lefler, Talent Search, is leaving the country for a year or more. A new chairman will be needed and also more funds. Seventy persons signed the roll.

H. E. Crull, Secretary

Approved 10-17-57

DINNER MEETING

May 10, 1957

6:30 C. D. T.

Turkey Run Inn

Words of welcome were given by the president W. H. Johnson and an introduction of officers. Out-of-staters were introduced. There were two present. There was a report of the afternoon executive meeting. Resolutions expressing thanks to the park management and program committee for a fine meeting were introduced and passed unanimously. Field trips were announced.

H. E. Crull, Secretary

MINUTES OF THE EXECUTIVE COMMITTEE

DePauw University, Greencastle, Indiana
October 17, 1957

The Executive Committee of the 73rd Session was called to order by President Johnson in Room 221, DePauw Student Building, at 7:30 p.m.

The minutes of the Spring Meeting held at Turkey Run State Park were read and approved.

Treasurer. Dr. Frank Welcher gave the following financial report for the time period January 1, 1957 to December 31, 1957. This report and those for 1955 and 1956 have been audited. The 1955 and 1956 financial reports were not received by Dr. W. P. Morgan, Chairman of the Auditing Committee, until June 19, 1957.

Receipts

1.	Balance on hand January 1, 1957	$1,806.81	
2.	Dues and initiation fees	3,039.00	
3.	Publications sold	167.62	
4.	Authors' reprints, Vol. 63	9.66	
5.	Authors' reprints, Vol. 66	328.92	
6.	Designated gifts	6,500.00	
7.	Talent Search	3,000.47	
			$14,852.48

Disbursements

1.	Editor, Vol. 66	$ 258.79	
2.	Expenses of President	10.00	
3.	Expenses of Secretary	93.84	
4.	Expenses of Treasurer	182.41	
5.	Stationery	139.48	
6.	Talent Search	1,256.40	
7.	Program Committee	361.85	
8.	Research grants	150.00	
9.	Secretary of State	1.00	
10.	Mailing Proceedings, Vol. 66	50.83	
11.	Returned Check	4.00	
12.	Expenses of six officers as directed by action of 1947 Executive Committee	125.00	
13.	Academy Conference	12.00	
14.	Designated gift	50.00	
15.	Reprints, Vol. 65	941.40	
16.	John Shepard Wright Memorial Library	638.96	
17.	Expenses of Nominating Committee	5.67	
18.	Junior Academy of Science	19.55	
19.	Publication of Proceedings, Vol. 64	8.27	
20.	Publication of Proceedings, Vol. 65	1,073.10	
			$ 5,382.55
	Balance on hand December 31, 1957		9,469.93
			$14,852.48

The balance on hand December 31, 1957, includes $5,761.04 in the John Shepard Wright Memorial Library fund.

FRANK J. WELCHER,
Treasurer

Received material for audit April 9, 1958. Records checked and found correct.

W. P. Morgan, Chairman Audit Committee

Editor—Richard A. Laubengayer: The current Volume 66, 1957, of the Proceedings was mailed early in September. 1,200 hard bound and 400 soft bound copies were ordered from the printer. The volume is a fairly large one, larger than last year's. The volumes were mailed through the courtesy of the State Library, Miss Coats in charge. Because of the increase in printing costs, the Academy will have to contribute to the printing costs. This year the editor will abide strictly to the rule of eligibility and the deadline for sending in of manuscripts. After the deadline, no papers will be accepted. Because of the increase in printing cost, the Academy must be willing to help financially or else face small volumes. This coming year will be a difficult one because of the printing of the entire membership list. Plans should be made for the ten-year index both financially and otherwise. Review of the reprint situation in regard to the cost in particular. The Soils division was put in with Geology-Geography division. There was considerable discussion regarding the cost of reprints. Suggestion was made of possible subsidization.

Trustees of the Academy. Report by Harry E. Crull:

October 1, 1956 Beginning Balance		$ 1,155.08
October 1, 1956, to September 30, 1957 Total Receipts		403.67
October 1, 1956, to September 30, 1957		
Bank Fees	$ 20.18	
Transferred to Principal	948.36	
Interest	5.70	
Total Disbursement		974.24
September 30, 1957, Ending Cash Balance		584.51
Bonds and shares of stock—total carrying value		14,360.36

Press Secretary—James Clark: Announcement of meetings have been given to newspapers, radio and scientific magazines. Frank White devoted his column, which appears in newspapers over the state, to a paper on Redbud given at last year's meeting. Miss Coats deserves thanks from the Academy and myself for the excellent publicity concerning the Lilly donation to the Academy library.

Research Grants Committee—T. G. Yuncker: Two grants were made during the year. One to Dr. Carrolle Markle of Earlham for $100 to aid her in continuing her study of the flora of that region, and one to Dr. Welch to help her in her work on the Hookeriaceae and other mosses. We point out the publication of Dr. Welch's Mosses of Indiana by the Department of Conservation. This work has been aided by grants from the Academy and is an example of the good they are doing. There are no applications for any grants.

Nominations Committee—Raymond T. Girton: Chairman of the Bonding of Trustees Committee, Scott McCoy (biologist), Technical

High School, Indianapolis; second member, R. E. Cleland (botanist), Indiana University. Member of the Research Grants Committee, J. F. Hart (geographer), Indiana University (1962).

Fellows Committee—W. R. Breneman: The following persons are recommended to the Executive Committee of the Academy for nomination and election as Fellows: E. J. Asher, Department of Psychology, Purdue University; G. B. Bachman, Department of Chemistry, Purdue University; William Bloom, Department of Biology, Valparaiso University; Charles Brumfiel, Department of Mathematics, Ball State University; J. E. Christian, Department of Pharmacy, Purdue University; Sears Crowell, Department of Zoology, Indiana University; Donald Hamilton, Agricultural Research Service, Vincennes, Indiana; Georg K. Neumann, Department of Anthropology, Indiana University; John V. Osmun, Department of Entomology, Purdue University; Philip Peak, School of Education, Indiana University; Norman Pounds, Department of Geography, Indiana University; K. M. Seymour, Department of Chemistry, Butler University.

Biological Survey—C. A. Markle: Reports have been submitted on work on flora and fauna of Indiana, indicating whether in progress, completed but not published, or published in 1956-57. Questionnaires were sent to heads of Departments of Biological Sciences in the colleges and universities of the state asking what had been completed or published during 1956-57. The publications list and summary or work in progress follows:

Publications of 1956-57 Dealing with Flora and Fauna of Indiana

Biotic Group	**Published Work, author, etc.**
Algae	A Rare Dinoflagellate New to Indiana. William A. Daily. Proc. Ind. Acad. Sci. 66:300 (1957)
Fungi	Higher Fungi of Marion County, Indiana, VIII, John O. Cottingham. Proc. Ind. Acad. Sci. 66:305 (1957)
Bryophytes	Mosses of Indiana. Winona H. Welch. Published by Division of Forestry, Ind. State Dept. of Conservation, 1957
Vascular plants	Contributions to the Flora of Wayne County, Indiana, II, Carrolle A. Markle. Proc. Ind. Acad. 66:301-304 (1957)
Insecta	The orders Protura and Diplura in Indiana. Dr. L. Chandler, Proc. Ind. Acad. Sci. 66:112-114 (1957)
	Records of Indiana Coleopters, Dr. N. M. Downie, Proc. Ind. Acad. Science 66:115-125 (1957)
	A preliminary annotated list of the Apoidea, Dr. B. Elwood Montgomery, Proc. Ind. Acad. Sci. 66:125-140 (1957)
	Record of Zoraptera in Indiana, Riegel, G. T. and Koestner, E. J. Amer. Midl. Nat. 57(2):512 (1957)
	Some ectoparasites from Indiana mammals. Nixon Wilson J. Mamm. 38(2):281-282. (May 1957)
	Unusual abundance of Sandalus in southern Indiana. Frank N. Young. Coleopterist's Bulletin 9(5):74 (1955)
	Variations in temperature in small aquatic situations (includes notes on Indiana aquatic Coleoptera). Young, Frank N. and J. R. Zimmerman, Ecology 37(3):609-611 (1956)

Biotic Group	**Published Work, author, etc.**
Insecta	Euphydras Phaeton in southern Indiana. Frank N. Young, Lepidopterist News 10(1-2):46 (1956)
	Orthoptera of relict prairie fragments in Greene County, Indiana. Proc. Ind. Acad. Sci. 65:111-115 (1956). Young, Frank N. and I. J. Cantrall
	A preliminary key to the species of Hydrovatus of the Eastern United States (includes Indiana species of Coleoptera) Frank N. Young. Coleop. Bull. 10(3):53-54 (1956)
Fishes	Ecology of the central mudminnow, Umbra Limi. Richard S. Peckham and Clarence F. Dineen. Amer. Mid. Nat. 58(1):222-231 (1957)
Amphibians and Reptiles	Analysis of Post-Wisconsin biogeography of the prairie peninsula based on distributional phenomena among terrestrial vertebrate populations. Philip W. Smith. Ecology 38:205-18 (1957)
	Relationships of the redbacked and zigzag Plethodon in the west. Thurow, Gordon R. Herpetologoca 13:91-99 (1957)

Work in progress or completed 1956-57 dealing with Flora and Fauna of Indiana

Biotic Group	**Specific Title or Coverage, and workers**
Algae	Planktonic coccoid Myxophyceae of Indiana, W. A. Daily
Vascular Plants	Grasses (Tripsaceae). Lois Farquharson
	Helianthus monograph. Charles B. Heiser
	Desmodium, variation in selected species. Jack Humbles
	Floodplain vegetation of the Wabash and Tippecanoe Rivers. A. A. Lindsey
	Contributions to the Flora of Wayne County, Indiana. Carrolle A. Markle
	Sedges of Indiana. Mrs. Helene Starcs
Annelida	The earthworms of Indiana. Dr. L. Chandler
	Some freshwater oligochaetes and biology of local opilionids. Dr. C. J. Goodnight
	Earthworms of Wayne County. James Joyner
Insecta	The life history of Malitoma taurea. Dr. L. Chandler
	The social wasps of Indiana. Dr. L. Chandler
	The sand wasps of Indiana. Dr. L. Chandler
	The bees of Indiana (embryonic development). Dr. L. Chandler
	The cuckoo-wasps of Indiana (embryonic development) Dr. L. Chandler
	The ecological life history of Halictus ligatus Say with notes on related species. Dr. L. Chandler
	The life history of Melissodes bimaculata Lepeletier. Dr. L. Chandler.
	Records of Indiana Coleoptera. Dr. N. M. Downie
	The Anthophilous Insects of Indiana—additions to lists of Apoidea and Diptera; other Hymenoptera and other orders. Dr. B. Elwood Montgomery
	The Odonta of Indiana. Dr. B. Elwood Montgomery

Biotic Group	**Published Work, author, etc.**
Insecta	The insects of the soil; pond and lake margins and bottoms. Dr. B. Elwood Montgomery
	The insect fauna of the black locust in Indiana. Dr. Elwood Montgomery
	An annotated list of the flower-visiting Diptera. Dr. B. Elwood Montgomery
	Taxonomic and ecological survey of the mosquitoes of Indiana specimens deposited in the Purdue Entomology Collection. Frederick Schmidt, cooperating with the Department of Entomology, Purdue University
	Revision of the Genus Hesperotittix. Dr. Herbert S. Wallace
	The ectoparasites of Indiana mammals with especial reference to those of bats. Nixon Wilson
	Studies on seasonal distribution, habitat and interspecific competition in the genus Laccophilus. (Study of Indiana species of aquatic Coleoptera). J. R. Zimmerman
Reptiles and Amphibians	A distributional summary of the herpetofauna of Illinois and Indiana. S. A. Minton and Philip W. Smith
	Another report of Cemophora from Indiana and a note on egg-laying. S. A. Minton and H. B. Bechtel
Mammals	Indiana Bats and their distribution. James B. Cope
	The mammals of Ripley County. Dwight Lindsey

The conclusion was reached that this information should in the future be made available through the Proceedings.

Library Committee—Nellie M. Coats: In May, 1957, a report was made upon a grant of $6,400 by Lilly Endowment, Inc. to complete certain files of library materials, to bind some of the earlier volumes, and to purchase a display case to be used to illustrate the library's geographic and subject range and to place its name in greater prominence. Dealers in American and foreign periodicals have been asked to quote prices on selected missing items but to date no bids have been received. It is thought to be difficult to locate the desired numbers, all of which are long since out of print. A handsome bronze display case was purchased at a cost of $592.00. The case has been placed in the entrance lobby of the Indiana Library and Historical Building where it will readily be seen by visitors to any part of the building. On October 3, officers of the Academy, the Director of the State Library, and members of its staff most directly concerned assembled to greet Mrs. John S. Wright for whose husband the Academy is named, to note the 50th year of an arrangement for its care Mr. Wright had made with the State Library, and to express gratitude to the Lilly Endowment for the grant. The Academy Proceedings, V 66, 1956, was published August 22, 1957. 855 copies have been mailed to members. A few single volumes of the Proceedings have been sold from time to time, an unusual sale in 1957 was that of 43 volumes to Kraus Periodicals. Among notable acquisitions was a gift of 60 volumes of a Czech mathematical journal sent from Prague and valued at $200. At the May meeting it was pointed out that articles in the Proceedings are cited in some eleven well-known abstracting and indexing publications such as Chemical Abstracts. To these has been added the Zoological Record as suggested by a member of the Executive Committee.

The list of these services will appear on the verso of the title page of the next issue of the Proceedings.

Invitations Committee—Winona Welch: Marian College of Indianapolis, Indiana, has invited the Academy to meet on the Campus in the fall of 1958. The Executive Committee voted to accept the invitation.

Membership Committee—H. R. Youse: A total of 47 members have joined the Academy this year.

Program Committee—H. R. Youse for Dr. Yuncker: All in readiness for Friday and Saturday. 130 reservations have been made for the dinner.

Junior Academy—H. H. Michaud: The twenty-fourth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 13, 1956, in Jordan Hall of Indiana University, Bloomington, Indiana. Approximately 250 high school students, teachers, and guests registered at the meeting. The day's program consisted of career conferences conducted by representatives of the science faculty of Indiana University, visits to the campus science laboratories, exhibits of science projects and papers by high school science club members. Included among the exhibits were a television set adapted for short-wave reception, a mineral collection, a demonstration study of paramecia, an automatic Wilson cloud chamber, a flat cathode-ray tube, and others. Fourteen papers were presented by high school club members. Two new high school science clubs have joined the Junior Academy since last year. They include the Guerin Science Club, Ladywood School, Indianapolis, and the Shawe Science Club, Fr. Michael Shawe Memorial High School, Madison. There are now forty-nine clubs listed on the roll of the Junior Academy. At least two-thirds of these are active and some on the inactive list have recently promised to reorganize. The 25th annual meeting of the Junior Academy will convene this Saturday, October 19. The program of papers will be presented at Maharry Hall of DePauw University. Eleven papers will be read by Junior Academy members during the afternoon session. Arrangements have been made through Dr. L. S. McClung, Department of Bacteriology, Indiana University, to show a motion picture on "A Career in Bacteriology." The Junior Academy Council last year decided to publish a mimeograph edition of the Junior Academy Journal primarily for high school club sponsors. One issue was completed last spring and a second is nearly ready for distribution. The Journal included abstracts of student papers given at the annual meeting and offered suggestions for science club activity. In addition to the Journal the officers of the Junior Academy publish an annual News-letter which reports activities of the various Junior Academy clubs over the state.

Indiana Science Talent Search—Richard Schultz for R. W. Lefler: One hundred forty-three Indiana high school seniors completed entry requirements for the 1956-57 Science Talent Search. One hundred nineteen of these students will attend 39 colleges; 91 in 18 Indiana colleges and 26 in 21 out-of-state schools, while 2 are undecided as to the college they will attend. Those students who will attend college have chosen the following curricula: Engineering, 44; Medicine, 11; Physical Sciences, 33; Non-Science areas, 13; Biological Sciences, 6; Mathematics, 3; Nursing, 5; and Undecided, 5. Of the remaining 24 students 2 are going to college next year, one is working, two are in the armed services of the United States and 19 have not reported. This year it is known that 62 of our participants have been awarded scholarships by the colleges they will attend. Fifty-four of these scholarships have associated stipends ranging from remission of fees to $6000 for the four year period of undergraduate study. The total financial aid which these students will receive in support of their undergraduate program will be over $70,000. This is, of course, dependent on these students maintaining an appropriate level of academic performance. The Junior Scientists' Assembly was held on March 23, 1957, in Indianapolis. In addition to the exhibit of projects by the Indiana Winner-Honorable Mention Group the usual program at the Honor's Luncheon, our Winner-Honorable Mention students and their sponsoring teachers were the guests of the Research Division of the Eli Lilly Company during the day, Friday, March 22, and of the Allison Division of General Motors for Friday evening. The Indiana Science Talent Search for 1957 is made possible by the generous support of Kappa Kappa Kappa, an organization of Indiana women for the furtherance of Art, Culture and Scholarship, and members of the Indianapolis Chamber of Commerce and the Indiana State Chamber of Commerce. We expect to hold the Junior Scientists' Assembly for the 1957-1958 school year on March 22, 1958.

Science Education—Dr. Johnson: Dr. Johnson reported that the application for aid in this area presented to the National Science Foundation was refused.

New Types of Membership—H. M. Powell: The committee reported the following: Husband and wife membership, with one joint copy of the Proceedings and either or both being eligible for presentation of papers and any other privileges, shall be $6 per year. Sustaining membership for individuals, companies and similar organizations shall be $25 per year.

New Business—On recommendation of the secretary in accordance with Art. II, Sec. 5 of the Constitution, Dr. Alvin Strickler and Dr. Karl Means were voted emeritus membership in the academy. In recognition of their services to the Academy it was voted that they receive the Proceedings.

Dr. Frank Welcher read a list of the supporters of the Science Talent Search. These were industrial concerns whose aid was obtained through the efforts of the Indiana and Indianapolis Chambers of Commerce.

Mr. Richard Shulz, who will work with the Junior program during Dr. Lefler's absence, was introduced and outlined his plans for the future work in this field. During the ensuing discussion of the Science Fairs it was decided that the Committee on Science Education should serve in an advisory capacity for Science Fairs, thus officially representing the Academy in this area.

The meeting adjourned at 10:50 p.m.

H. E. CRULL, Secretary

Approved: October 18, 1956

MINUTES OF THE GENERAL SESSION

DEPAUW UNIVERSITY, OCTOBER 18, 1957

Dr. Robert H. Farber, Dean of DePauw University, welcomed the Indiana Academy of Science to the Greencastle campus. A response was given by Dr. Willis H. Johnson, President of the Indiana Academy of Science.

The minutes of the Executive Committee were read and approved.

Dr. Wm. E. Edington presented a short biographical sketch of members who had died during the year. They were Arthur Fisher Bentley, Herbert P. Bybee, Joseph Bernard Hershman, John Hobart Hoskins, Henry Augustus Huston, Walter Albert Jamieson, Henry Reist Kraybill, Philip Luginbill, Daniel Charles O'Grady, Guy Stanz, and Sister Carmella Welte.

Dr. George F. Reddish, Chief Bacteriologist, Lambert-Hudnut Division of Warner Lambert Pharmaceutical Company and Professor of Microbiology and Public Health, St. Louis College of Pharmacy and Applied Sciences, St. Louis, Missouri, presented an address entitled "Present Trends Relating to Antiseptics, Disinfectants and Sterilization." This was followed by a film entitled "A Career in Bacteriology."

The meeting adjourned at 11:00 a.m.

Sectional meetings then began with a recess for lunch, after which meetings were resumed.

The annual dinner was held in the Ballroom of the Union Building.

Vice-president Wm. A. Daily introduced the guests and officers at the speakers' table.

Prof. R. E. Cleland presented the following resolution:

"When it was announced a year ago that the Seventy-Third Annual Meeting of the Academy would be held at DePauw University, the distinct murmur of approbation which greeted the news, and the pleased expression on the faces of those assembled, were clear evidence of the fact that DePauw is known as a place where one is sure of a warm welcome and of thoughtful and efficient hospitality.

"This probably accounts for the fact that an unusually large proportion of Indiana's scientists have found their way to Greencastle in anticipation of a well-organized meeting amid delightful surroundings. Nor have they been disappointed. DePauw has fully measured up to her reputation and has made our visit both convenient and comfortable. The Indiana Academy of Science therefore wishes to record its deep appreciation to President Humbert and the other officers of the University, to the manager of the Union and his staff, and to the local committee who, under the able leadership of Prof. Yuncker and later Prof. Youse, have contributed so graciously to our welfare. For their labor of love, the Academy extends its gratitude and best thanks."

Dr. H. R. Youse presented a tentative list of 47 applicants for membership. These were duly elected.

The **Nominations Committee** report was given by the Chairman, R. E. Girton. Divisional chairmen for 1958 will be: Anthropology, Emily Blasingham, Indiana University; Bacteriology, Walter A. Konetzka, Indiana University; Botany, Mrs. Fay Daily, Butler University; Chemistry, E. T. McBee, Purdue University; Entomology, John Favinger, State Department of Conservation; Geology and Geography, John Fraser Hart, Indiana University; History of Science, Howard Michaud, Purdue University; Mathematics, Irving Burr, Purdue University; Physics, Lewis Salter, Wabash College; Plant Taxonomy, Marion Hall, Butler University; Psychology, George Lovell, Wabash College; Zoology, William Hopp, Indiana State.

The following members were recommended to serve as 1958 officers: President, W. A. Daily, Eli Lilly Co.; Vice-President, A. A. Lindsey, Purdue University; Secretary, H. E. Crull, Butler University; Treasurer, F. J. Welcher, Indiana University; Editor, R. A. Laubengayer, Wabash College; Press Secretary, F. N. Young, Indiana University.

President Johnson gave his presidential address on "Undergraduate Curricula in Biology."

The 73rd annual fall meeting of the Indiana Academy of Science with a general attendance of 378 people and a dinner attendance of 141 was adjourned.

HARRY E. CRULL, Secretary

MEMBERSHIP[1]

Adams, Norval E., 120 N. Vine St., Elkhart, Ind. Bo, Z
Adams, Dr. S. Clifford, Box 217, Hanover, Ind. G
Adams, William B., 703 Anita St., Bloomington, Ind. Bo
*Addington, Prof. A. R., Fresno State Col., Fresno, Calif. G
Ae, Shigeru Albert, Box 126, Notre Dame Univ., Notre Dame, Ind. Bo, Z
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Albright, Lewis E., Psychology Dept., Purdue Univ., W. Lafayette, Ind. Ps
Aldred, Dr. Jacob Wm., H., R. R. 3, Florence, Ala. C
Alexander, Prof. Gerald L., 601 Alden Rd., Muncie, Ind. C
Alexander, Paul Stephen, Biology Dept., Northwestern State College, Natchitoches, La. Bo, Z
Alexander, Raymond Louis, 1695 Francis St., Franklin, Ind. Bo, Z
*Allen, Dr. Frederick John, Chemistry Dept., Purdue Univ., W. Lafayette, Ind. C
Allen, M. Ann, Botany Dept., Ind. Univ., Bloomington, Ind. Bo, Z
Allmon, Ross H., Hercules Powder Co., 332 S. Michigan Ave., Chicago 4, Ill. E
*Allyn, Dr. William Preston, Ind. State Teachers Col., Terre Haute, Ind. E, Z
Alter, Chester, Chancellor, Univ. of Denver, Colorado C
Amidei, Terso Paul, 4487 Monroe St., Gary, Ind. Bo, Z
Angrick, Warren Lewis, 5874 Central Ave., Indianapolis, Ind. Bo, Z
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*Asher, Prof. E. J., Psychology Dept., Purdue Univ., W. Lafayette, Ind. Ps
*Ayres, Prof. W. L., Math Dept., Purdue Univ., W. Lafayette, Ind. M

Babcock, Robert F., Standard Oil of Indiana, Technical Services Div., Whiting, Ind. C
Babcock, Wm. C., Jr., Rensselaer, Ind.
*Bachman, G. Bryant, Chemistry Dept., Purdue Univ., W. Lafayette, Ind. C
Bachofer, Prof. C. S., C.S.C., Univ. of Notre Dame, Notre Dame, Ind. Ba
*Badertscher, Prof. J. A., 1302 E. Hunter Ave., Bloomington, Ind. Z
Baker, Dr. Lawrence Manning, Psychology, Biology Annex, Purdue Univ., W. Lafayette, Ind. Ps

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[1] For the benefit of sectional chairmen in the preparation of programs, each member has been asked to indicate the section or sections in which most interested. Preferences are indicated as follows: A, Anthropology; Ba, Bacteriology; Bo, Botany; C, Chemistry; E, Entomology; G, Geology and/or Geography; H, History of Science; M, Mathematics; Ph, Physics; PT, Plant Taxonomy; Ps, Psychology; Z, Zoology. If no letter follows the name, the information is lacking.

* Indicates Fellow

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Banta, Edna, Mary Gray Bird Sanctuary, R. R., Connersville, Ind. Bo, Z
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Barber, Dr. Stanley A., Agronomy Dept., Purdue Univ., W. Lafayette, Ind. Bo
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Bartle, Dr. Glenn Gardner, Harpur Col., Endicott, New York G
Barton, James D., Jr., Boston Univ., Jr. Col., 688 Baylston St., Boston, Mass. Bo
Barton, Dr. Jay, II, St. Joseph's Col., Collegeville, Ind. Z
*Barton, Prof. Thomas F., P. O. Box 312, Bloomington, Ind. G
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Beals, Harold O., Biological Science Dept., Purdue University, W. Lafayete, Ind. PT
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Beekman, Bruce Edward, Zoology Dept., Ind. Univ., Bloomington, Ind. Z
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Bender, Prof. Paul, Goshen, Ind. Ph
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*Cooper, Robert, Biology Dept., Ball St. Teachers Col., Muncie, Ind. E, Ba, Bo, Z
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Cover, H. S., Chippewa Knoll, South Bend, Ind. M
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*Deay, Howard Owen, Entomology Dept., Purdue Univ., W. Lafayette, Ind. E, Z
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DeVol, Prof. Charles E., Marion Col., Marion, Ind. Bo, Ba
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Smith, Robert E., 1515 N. Chester, Indianapolis, Ind.	Z
Smith, Mrs. Vivian D. Jeffers, 323 Elm St., Lawrenceburg, Ind.	Bo, Z
Smithberger, Andrew T., 2085 Oakmont Park, E. Dr., South Bend, Ind.	
Smolar, Rev. Joseph, St. Joseph's Col., Collegeville, Ind.	Bo, Z, C
Smucker, Silas J., 403 S. Weston St., Rensselaer, Ind.	Bo
Somers, Perrie D., Jr., 9912 Harriet Ave., So., Minneapolis, Minn.	C
*Sonneborn, Dr. Tracy M., Zoology Dept., Indiana Univ., Bloomington, Ind.	Z
Sowders, Ted M., 3214 N. Bolton Ave., Indianapolis, Ind.	Ph
Spangler, Iva, 128 E. Foster Pkwy., Ft. Wayne, Ind.	Bo, Z
Spencer, Dr. Joseph Nuten, R.R. 6, Box 634, Terre Haute, Ind.	Z, Bo, C
Speroff, B. J., 819 Conkey St., Hammond, Ind.	Ps
Sperry, Dr. Theodore M., Biology Dept., Kansas State Teachers Col., Pittsburg, Kans.	Bo, Z
Sprague, Dr. Austin, 1008 S. College, Greencastle, Ind.	Ph
Stanley, Dr. Paul E., School of Aeronautical Engineering, Purdue Univ., W. Lafayette, Ind.	Ph
Stanley, Dr. Robert W., Physics Dept., Purdue Univ., W. Lafayette, Ind.	Ph
Starcs, Mrs. Helene, 2915 Guilford, Indianapolis, Ind.	Bo
Stark, Ralph W., 122 Lebanon St., Lebanon, Ind.	Bo
Stark, Wm. Max, Microbiological Res. Dept., Eli Lilly & Co., Indianapolis, Ind.	Ba

*Starkey, Prof. Otis Paul, Geography Dept., Indiana Univ., Bloomington, Ind. G
Starr, Dr. Richard C., Botany Dept., Indiana Univ., Bloomington, Ind. Bo
Stearns, Forest, Botany & Plant Path. Dept., Agr. Exp. Sta., Purdue University, W. Lafayette, Ind. Bo
Steinmetz, Charles H., 2009 Dale Rd., Norwood (Cincinnati 12), Ohio Z
Stephenson, Wm. K., Earlham Col., Richmond, Ind. Z
Stevenson, Dr. Forrest F., 3529 Peach Tree Lane, Muncie, Ind. Bo
Stevenson, Prof. William H., Ball State Teachers Col., Muncie, Ind. G
Stewart, Lola, 341 McKinley St., Gary, Ind. Bo, Z
Stitt, Loyd L., 321 W. Prairie Ave., Wheaton, Ill. E
*Stockdale, Dr. Paris, Geology Dept., Univ. of Tennessee, Knoxville, Tenn. G
Stockton, Sister Mary Rose, Marian Col., 3200 Cold Springs Rd., Indianapolis, Ind. C
Stone, Prof. Ralph Bushnell, 615 Russell St., W. Lafayette, Ind. M
Stone, Dr. Robert L., Lilly Research Laboratory, Eli Lilly and Company, Indianapolis, Ind. Ba
Stork, Mary Louise, 218 Thirteenth Ave., North, St. Petersburg, Fla. Ba, C, Bo
Strain, Dr. Edward R., 113 Lindenwald Dr., Indianapolis, Ind. Ps
Streightoff, Frank, 250 N. Home Ave., Franklin, Ind. Ba
*Strickler, Dr. Alvin, 312 Michigan Ave., Frankfort, Mich. C
Stuck, Mrs. Dollie N., 1309 N. Penn. St., Indianapolis, Ind. Bo
Sturm, Richard C., 925 Southern Ave., Indianapolis, Ind. Bo
Sullivan, Gerald, R.R. 3, Box 342, Elwood, Ind. Bo, Z
Sullivan, Russell, 2908 N. Meridian St., Indianapolis, Ind. M, Ph
Sulzer, Elmer G., Indiana Univ., Bloomington, Ind. G
Sutter, Delos M., 2018 Westfield Terr., Bethlehem, Penn. Ph
Suttle, S. Woodrow, Indiana State Teachers Col., Terre Haute, Ind. Z
Swanson, Edward E., 7920 Barlow Dr., Indianapolis, Ind. Bo, C
Swickard, Dayton A., 215 Stratton Way, Decatur, Ind. Ba, Bo, Z

Taggart, Matt F., R.R. 3, Box 31, Cassopolis, Mich. C
Tallman, Dr. Arthur Wince, 179 Hudson Terr., Piermont, N. Y. Ba, C
Talvenheimo, Dr. Gerhart, P.O. Box 427, Marcus Hook, Penn.
Tasker, Dr. Roy C., Biology Dept., Bucknell Univ., Lewisburg, Penn. Bo, Z
Taylor, John G., Agr. Eng. Dept., Purdue Univ., W. Lafayette, Ind. Ph
Teder, John H., Jasper, Ind. Bo
Telfair, Dr. David, Earlham Col., Richmond, Ind.
*Tetrault, Philip Armand, 235 DeHart St., W. Lafayette, Ind. Ba, C
Thanos, Dr. Andrew, Dept. K-490, Eli Lilly & Co., Indianapolis, Ind. Bo
*Thomas, Prof. Tracy Yerkes, N. Fee Lane, R.R. 10, Bloomington, Ind. M
Thomas, Virgil A., 83 W. Main St., Greenfield, Ind. G, Bo, Z
Thompson, Harold B., 8501 Wicklow, Cincinnati 36, Ohio Ph
Thomson, William David, Geology Dept., Indiana Univ., Bloomington, Ind. G
Thornburg, Noel G., 538 S. Main St., Parker, Ind. Bo

*Thornbury, William D., Geology Dept., Indiana Univ., Bloomington, Ind. G
Thorp, Prof. James, Earlham Col., Richmond, Ind. G
Tinkle, Dr. Wm. J., Biology Dept., Anderson Col., Anderson, Ind. Bo, Z
Toms, William L., Indianapolis News, Indianapolis, Ind. A
*Torrey, Dr. Theodore W., Zoology Dept., Indiana Univ., Bloomington, Ind. Z
Touloukian, Dr. Y. S., School of Mech. Eng., Purdue Univ., W. Lafayette, Ind. Ph
Trabant, Prof. E. A., 215 Forest Hills Dr., W. Lafayette, Ind. M
Traynelis, Dr. V. J., Chemistry Dept., Univ. of Notre Dame, Notre Dame, Ind. C
Trefz, Mrs. Lettie Page, 953 N. Audubon Rd., Indianapolis, Ind. Bo
Trimble, Dr. Otis Carroll, 7802 Wildwood Dr., Tacoma Park 12, Md. Ps
Trippel, Albert W., 904 E. 75th St., Auburn, Ind. Z
Truman, Dr. Lee C., 6242 N. Temple Ave., Indianapolis, Ind. Z
Tryon, Rolla M., Jr., Botany Dept., Univ. of Calif., Berkeley 4, Cal. Bo
Tuan, Yi-Fu, Geography Dept., Indiana Univ., Bloomington, Ind. G
Turbes, Calvin C., D. V. M., 417 S. Fess St., Bloomington, Ind. C

Uible, Howard E., Route 2, Bethel, Ohio Ba, Bo, PT, E
Ullstrup, Dr. Arnold John, Botany & Plant Path. Dept., Purdue Univ., W. Lafayette, Ind. Bo
Ulman, P. T., R.R. 2, Noblesville, Ind. Bo, Z
Ulrich, H. P., Agr. Exp. Sta., W. Lafayette, Ind. G

Van Derbilt, Betty, 5131 Central Ave., Indianapolis, Ind. G
Van Dorn, Estil B., 1053 W. 35th St., Indianapolis, Ind. C, Ph
Van Dyke, Prof. George D., Earlham Col., Richmond, Ind. Ph
Van Horn, Marie, Coal City, Ind. C
Van Scoik, William S., 4009 Greendale Dr., Fort Wayne, Ind. E
Van Wagtendonk, Dr. Willem Johan, Jordan Hall, Indiana Univ., Bloomington, Ind. C, Z
Vaughn, Thomas H., Pabst Brewing Co., 310 Merchandise Mart, Chicago 54, Ill. C
Vig, Reuben J., 3023 W. Morris St., Indianapolis, Ind. G
*Visher, Dr. Stephen S., 816 E. 2nd St., Bloomington, Ind. G
*Voeglin, Dr. Charles F., Indiana Univ., Bloomington, Ind. A, G
Voeglin, Dr. Erminie, 528 Highland Ave., Bloomington, Ind. A
Volk, Dr. N. J., 1137 Glenway, W. Lafayette, Ind. Bo

Wagner, Kenneth A., Biology Dept., Norfolk Div., Col. of William & Mary, Norfolk, Va. Bo
Wahl, Lucille, 941 Hervey St., Indianapolis, Ind. Bo
Wakefield, Mrs. Eleanor K., Olivet College, Olivet, Mich. C
Waldschmidt, Rudolph Charles, 821 LaPorte Ave., Valparaiso, Ind. Ps
Wallace, Dr. Atwell Milton, Botany Dept., Ohio Univ., Athens, Ohio Bo, Z
Wallace, Charles E., Rossville, Ill. M, Ph, C
Wallace, Edith, 620 Van Buren St., Gary, Ind. Bo, Z

*Wallace, Frank N., 311 W. Washington St., Indianapolis, Ind. Bo, Z
Wallace, John H., Bausch & Lomb Optical Co., Scientific
Instruments Div., 1324 Eye St., N. W., Washington, D. C. Bo
Walter, E. V., Box 495, Lafayette, Ind. Z
Wampler, Lloyd C., 820 N. Center St., Plymouth, Ind. Z
Wantland, Kenneth W., 2108 Kessler Blvd., E. Dr., Indianapolis, Ind. C
Ward, Daniel B., 211 W. Pike St., Crawfordsville, Ind. Bo
Ward, Mrs. Gertrude L., Biology Dept., Earlham Col., Earlham,
Ind. Bo, Z
Warner, Dr. Glen W., Lakeville, Ind. Ph, M
Warren, Charles P., 6323 S. May St., Chicago, Ill. A
Wayne, Dr. William John, Geological Surv., Indiana Univ.,
Bloomington, Ind. G
*Weatherwax, Dr. Paul, Botany Dept., Indiana Univ.,
Bloomington, Ind. A, Bo
Weaver, Dr. E. Eugene, Wabash Col., Crawfordsville, Ind. C
Webb, Dr. Harold D., 812 W. Delaware St., Urbana, Ill. Ph
Webb, Laura Bernice, Franklin, Ind. Bo, Z
Webb, Prof. Richard L., 1408 Maxwell Lane, Bloomington, Ind. Z
Weber, Glen C., 1330 W. Michigan, Indianapolis, Ind. Ba, C
Weber, Robert Claude, 2724 Fairfield Ave., Fort Wayne, Ind. Bo, Z
Weber, Russell G., 416 Governor St., South, Iowa City, Iowa Bo, Z
Weber, Walter, 47 S. Pennsylvania St., Indianapolis, Ind. C, Bo, E
Webster, Dr. Jackson, Zoology Dept., Hanover Col., Hanover, Ind. Z
Webster, Dr. Rex N., 2101 N. Penn. St., Apt. 4, Indianapolis, Ind. Ba, Bo
Weddle, Mrs. Virginia, Dunwekin R.R. 4, Nashville, Ind. Bo, Z
Weigand, Dr. Clayton G., 5234 N. Capitol Ave., Indianapolis, Ind. Z
Weinberg, Dr. Eugene D., Bacteriology Dept., Indiana Univ.,
Bloomington, Ind. Ba
*Welch, Dr. Winona H., 112 Bloomington St., Greencastle, Ind. Ba, Bo
Welch, Dr. Zara D., Chemistry Dept., Purdue Univ.,
W. Lafayette, Ind. C
*Welcher, Dr. Frank, R.R. 13, Box 426, Indianapolis, Ind. C
Wells, Dr. Agnes E., 903 Court St., Saginaw, W. S., Mich. M
Wells, David, Crawfordsville Jr., Sr. H. S., 705 W. Water St.,
Crawfordsville, Ind. Ph, C
Wells, Dr. H. B, Indiana Univ., Bloomington, Ind.
Wells, Milo, 1590 Elbur Ave., Lakewood 7, Ohio Ph
Westmeyer, Paul H., Univ. H. S., Urbana, Ill. G
Whitacre, Francis M., 148 Shoreview Rd., Manhasset, Long
Island, N. Y. C
White, Dr. Harold K., Box 273, Hanover, Ind. C
White, Prof. Joe L., Agronomy Dept., Purdue Univ.,
W. Lafayette, Ind. G
*White, Dr. John, 2235 N. 10th St., Terre Haute, Ind. C
Whiting, Russell W., Service Mgr., Arab Pest Control Co.,
2701 Winthrop, Indianapolis, Ind. E
*Wickwire, Prof. Grant T., Geology Dept., Hanover Co., Hanover, Ind. G
Wier, Charles E., Geological Surv., Indiana Univ., Bloomington, Ind. G

*Wildman, Earnest A., Chemistry Dept., Earlham Col., Earlham, Ind. C, Ph
Wilhelm, Ernest John, 1422 E. LaSalle Ave., South Bend, Ind. C
Wilkinson, Paul D., Indiana State Teachers Col., Terre Haute, Ind. C
Wilkinson, Isaac Ross, R.R. 3, Angola, Ind. Bo, Z
Wilkinson, Stanley R., Agronomy Dept., Purdue Univ., W. Lafayette, Ind. G
Willer, William Arnold, Westwood, R.R. 3, Fort Wayne, Ind. Bo, Z, Ph
Williams, Dr. Eliot C., Jr., Zoology Dept., Wabash Col., Crawfordsville, Ind. Z
*Williams, Dr. Kenneth P., 702 E. 10th St., Bloomington, Ind. M
Wilson, Kenneth S., 6852 Magoun, Hammond, Ind. Bo
*Wilson, Mark Curtis, Entomology Dept., Purdue Univ., W. Lafayette, Ind. Bo, Z
Wilson, Nixon A., Entomology Dept., Purdue Univ., W. Lafayette, Ind. E, Z
Wimmer, Ruth M., 2222 Hoagland Ave., Apt. 3, Fort Wayne, Ind. C
Winkel, Theodore A., 607 N. East St., Madison, Ind. C
Winn, Richard E., Physics Dept., Indiana State Teachers Col., Terre Haute, Ind. Ph.
Wischnitzer, Saul, Biology Dept., Univ. of Notre Dame, Notre Dame, Ind. Z
Wise, Robert Elliott, Purdue Univ., Center, 220 E. Jefferson, Fort Wayne, Ind. M, Ph
Wiseman, Dr. P. A., 309 S. Nichols Ave., Muncie, Ind. C
Witmer, Dr. Samuel W., 1608 S. 8th St., Goshen, Ind. Bo, Z
Woerner, Dr. Dale E., Hanover, Col., Hanover, Ind. C
Wolfe, Harold E., 812 S. Fess Ave., Bloomington, Ind. M
Wolfe, Ruby, 3267 College Ave., Indianapolis, Ind. Bo, Z
Wollan, Gerhard N., 4606 Woodsdale Lane, Fort Wayne, Ind. M
Wood, Darl F., 201 Miami Club Dr., Mishawaka, Ind. G, Ph, C
Wood, Elmo S., Box 14, New Castle, Ind. C, Bo
Wood, Joseph M., Botany Dept., Indiana Univ., Bloomington, Ind. Bo
Wood, Vida G., Taylor University, Upland, Ind. Bo
Woods, Prof. Kenneth B., 902 N. Chauncey Ave., W. Lafayette, Ind. G
Worrell, Prof. Francis T., DePauw Univ., Greencastle, Ind. Ph
Wrathall, James E., 33 Green Ave., Devenham, Northwich, Cheshire, Eng. G
Wright, Howard F., 3604 N. Temple, Indianapolis, Ind. Ba, Bo, Z
Wright, Dr. Jonathon W., Morris Arboretum, Chestnut Hill, Philadelphia, Pa. Bo
Wuest, Rev. Albert A., Chemistry Dept., St. Joseph's Col., Collegeville, Ind. C
Wykoff, Jack N., Earlham College, Richmond, Ind. Z

Yarian, Dean R., Chemistry Dept., Univ. of Washington, Seattle, Wash. C
Yarnelle, Dr. John E., Mathematics Dept., Hanover Col., Hanover, Ind. M
*Young, Dr. Frank N., Jr., Zoology Dept., Indiana Univ., Bloomington, Ind. E, Z

Youse, Howard Ray, Botany Dept., DePauw Univ., Greencastle, Ind. Bo
*Yuncker, Dr. Truman G., University College of the West Indies, Mona, St. Andrews, Jamaica, B. W. I. Ba, Bo

Zakewska, Barbara, 4610 W. 115th Place, Alsip, Ill.
Zeller, Frank J., Zoology Dept., Indiana Univ., Bloomington, Ind. Z
*Zerfas, Dr. Leon G., Box 70, R.R. 1, Camby, Ind. Ba, Z
Zetterberg, Edward, 1101 N. Jefferson St., Muncie, Ind. C
Zieroff, Sister Gertrude Marie, Marian Col., 3200 Cold Springs Road, Indianapolis, Ind. M
Zimmerman, Harold A., 2218 Linden St., Muncie, Ind. Z
Zirkle, Dr. George Anderson, Psychology Dept., Hanover Col., Hanover, Ind. Ps
Zorn, Dr. Max A., Mathematics Dept., Indiana Univ., Bloomington, Ind. M

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1957

President: Betty Jane Gough, Science Club, New Castle High School, New Castle.

Vice-President: Wilfred Day, Phy-Chem Club, Our Lady of Providence High School, Clarksville.

Secretary: Margaret Reynolds, Science Club, Washington High School, Indianapolis.

Members of the Council: Edith Wallace, Gary (1953-1957); Jerry Motley, Indianapolis (1954-1958); Jack Munsee, Bloomington (1955-1959); Ernest Litweiler, South Bend (1956-1960); Mrs. Elizabeth H. Crider, Indianapolis (1957-1961).

PROGRAM OF THE TWENTY-FIFTH ANNUAL MEETING

October 19, 1957

Assembly Room, Speech Hall, DePauw University, Greencastle, Indiana.

8:30-9:30 a. m. Registration and Placement of Exhibits, Rooms 122, 113, Harrison Hall.

9:40-10:30 a. m. Career conferences in mathematics and science by faculty representatives of DePauw University.

10:30-11:30 a. m. Visits to campus instructional and research laboratories.

11:30 a. m.-12:30 p. m. Luncheon, Union Cafeteria.

1:00-2:00 p. m. Business meeting and election of officers. Assembly Room, Speech Hall.

2:00-4:00 p. m. The Assembly Program, Assembly Room, Speech Hall.

Papers: Betty Jane Gough, presiding.

1. *X-ray Induced Mortality in the Common Gnat or Fruit Fly*, Terry Meyers, Junior Explorers of Science, Lebanon High School, Lebanon.
2. *Magnesium Production*, James Hartman, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne.
3. *Acceleration of Metamorphosis of Rana Catesbeiana (bullfrog) by the Use of Thyroid Extract*, Beverly Twigg, Adams Walton Club, Adams High School, South Bend.
4. *The M-wing and Its Possibilities*, Curtis Fischbach, Junior Academy of Science Club, Central-Junior High School, South Bend.

5. *Diamagnetism*, David Swinehart, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne.
6. *The Third Kingdom*, William Forgey, Biology Club, Lew Wallace High School, Gary.
7. *A Morphological Study of Early Regressive Changes in the Mammae of Male and Female Mice Upon the Removal of Estrogen Stimulation*, Julia Freeman, Science Club, Howe High School, Indianapolis.
8. *Slime Molds*, Hazel Cuffey, Junior Academy of Science Club, University High School, Bloomington.
9. *Terramycin Research on the Reproductive Organs of Chickens*, Gary Holobek, Science Club, Howe High School, Indianapolis.
10. Motion Picture—*A Career in Bacteriology*, edited by Drs. Leland S. McClung and Walter Konetzka, Department of Bacteriology, Indiana University.
11. *Microtechnique* (illustrated), Betty Jane Gough, Science Club, New Castle High School, New Castle.
12. *Bio-Con Arboretum*, Junior Academy of Science Club, South Side High School, Fort Wayne.

MINUTES

The twenty-fifth annual meeting of the Indiana Junior Academy of Science was held Saturday, October 19, 1957, in Harrison and Speech Halls of DePauw University, Greencastle, Indiana.

Eight exhibits of science projects by high school students were displayed in rooms 122 and 113 of Harrison Hall beginning at 8:30 a. m. The exhibits included a study of magnesium production, metamorphosis of the tadpole, trees for an arboretum, electronic lamp control, a mineral collection, and a model plane with M-wing design.

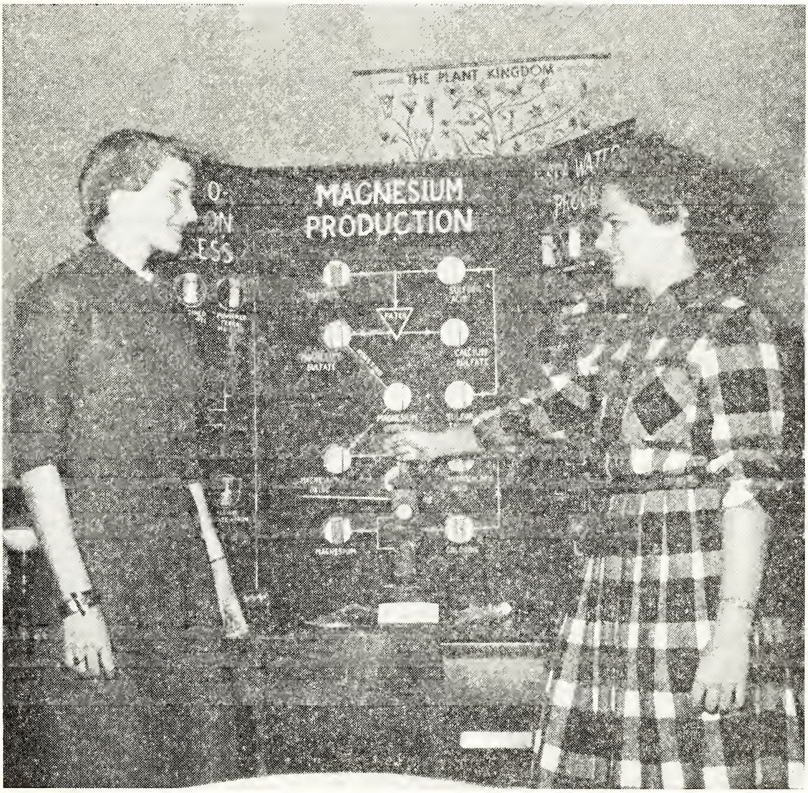
Career conferences in scientific fields were held at 9:40 a. m. by members of the faculty of DePauw University. The science areas from which students could choose included astronomy, botany, bacteriology, chemistry, geology, geography, mathematics, physics, psychology and zoology. The contributions by the DePauw staff were greatly appreciated by members of the Junior Academy. Faculty members who presented the career conferences also conducted informative tours of the science laboratories.

The annual business meeting was called to order at 1:00 p. m. in Speech Hall by the president, Betty Jane Gough of New Castle High School, New Castle. The new and old members of the Junior Academy were welcomed. The president expressed her thanks to each science club for the information received for the Junior Academy News-Letter. She also suggested that the secretaries of science clubs continue to send information that should be included in the News-Letter.

The president introduced Margaret Reynolds, Secretary of the Junior Academy. Vice President Wilfred Day, Our Lady of Providence High School, Clarksville, was not present. Thirteen science clubs responded to roll call read by the Secretary. It was announced that two new clubs were added in 1957 which included the Science Club, Shawe Memorial High School, Madison, and the Guerin Science Club, Ladywood High School, Indianapolis.

The minutes of the 1956 meeting were read by the Secretary and approved.

The next item of the business meeting was the election of officers. A list of nominees was submitted by the Council from names received from club sponsors and nominations were accepted also from the floor.



Officers of the Junior Academy for 1957 examine one of the Exhibits presented at the Annual Meeting. (l. to r.) Margaret Reynolds, Secretary, and Betty Jane Gough, President.

The officers for 1958 were elected as follows: president, Tom Joyce, Science Club, Central Junior-Senior High School, South Bend; vice-president, Terry Meyers, Junior Explorers of Science, Lebanon High School, Lebanon; secretary, Judy Francisco, Science Club, New Castle High School, New Castle.

Miss Edith Wallace, reporting for the Council, announced that Mr. Jack Munsee, Council member of University High School, Bloomington, had moved out of the state. Mrs. Mary Gough, New Castle, was appointed to complete Mr. Munsee's unexpired term. Robert Weber, sponsor of the science club, South Side High School, Fort Wayne, was selected as the new Council member to replace Miss Wallace whose term expired. Each of the five Council members serves a term of five years.

A special award of twenty-five dollars will be given at the 1958 annual meeting to the student writing the best paper on bacteriology or microbiology. The award is being offered by the Society of American Bacteriology. Judges will include one member each from the Society of American Bacteriology and the Indiana Academy of Science. The State Sponsor and Council of the Junior Academy expressed its grateful appreciation to the Society for its interest in providing this award.

Miss Edith Wallace announced also that the selection of the "Best Boy" award in science resulted in a tie. The award for 1957 therefore would go to both Terry Meyers, Junior Explorers of Science, Lebanon High School, Lebanon and Gary Holobek, Science Club, Howe High School, Indianapolis. The "Best Girl" in science award was won by Julia Freeman, Science Club, Howe High School, Indianapolis.

Honorable mention for "Best Boy" in science was received by Dave Swinehart, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne. Beverly Twigg, Adams Walton Club, Adams High School, South Bend, received honorable mention as "Best Girl" in science for 1957.

Professor H. H. Michaud, State Sponsor, Purdue University, introduced Dr. Howard Youse of DePauw University and publicly expressed the appreciation of the Junior Academy for the excellent facilities provided by DePauw University and for Dr. Youse's efforts in helping to make the 1957 meeting a success. Professor Michaud announced that the 1958 annual meeting will be held at Marian College, Indianapolis.

Professor Michaud stated also that the attendance at the 1957 annual meeting was less than it had been during the past five years. Many students and teachers were unable to attend this year because of the flu. Students were urged to strive for better attendance at the next annual session.

An invitation was extended to members giving their science papers during the afternoon program to give the same papers at the Purdue Sci-Math Assembly in November.

Miss Jerry Motley, Science Club Sponsor, Howe High School, Indianapolis, was thanked on behalf of the Junior Academy for her work as editor of the Junior Academy Journal.

Terry Meyers, Lebanon High School, opened the program of papers by explaining the effect of X-rays on the mortality of fruit flies.

"Magnesium Production" was the title of the paper given by James Hartman, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne. He explained the two commercial processes of magnesium production and then a process he had developed.

In the third paper of the afternoon, Beverly Twigg, Adams High School, South Bend, explained how her project demonstrated the effects of thyroxin upon the metamorphosis of the bullfrog tadpole.

An explanation of the M-wing design for planes and its disadvantages was given by Curtis Fischbach, Central Junior-Senior High School, South Bend. His main points were that the M-wing retains low friction benefits, keeps the center of gravity in the middle of the plane, and does not allow wing twist.

David Swinehart, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne, submitted a paper on "Diamagnetism."

An exhibit of minerals was displayed by William Forgey, Lew Wallace High School, Gary. The minerals were referred to in his talk as "The Third Kingdom."

The next paper, presented by Julia Freeman, Howe High School, Indianapolis, dealt with the effect of the removal of estrogen stimulation on the mammae of male and female mice.

Hazel Cuffey, University High School, Bloomington, highlighted her talk on slime molds with slides. The slime molds, which are unnoticed by most people, are neither completely plant nor animal.

"Terramycin Research on the Reproductive Organs of Chickens" was the title of the paper given by Gary Holobek, Howe High School, Indianapolis.

A motion picture, "A Career in Bacteriology," was enjoyed by all. This informative picture emphasized that a student going into a scientific field needed a well-rounded educational background.

Betty Jane Gough, New Castle High School, gave an illustrated talk on microtechnique. Her talk included the steps in preparing slides of both plant and animal tissues.

The concluding paper was a report entitled "Bio-Con Arboretum." This project was a club project of the Junior Academy of Science Club, South Side High School, Fort Wayne. An arboretum was developed in one of the city parks of Fort Wayne. Trees for planting were obtained by gaining the support and interest of numerous organizations of the city.

Approximately one hundred and eighty science club members, sponsors and guests attended the twenty-fifth annual meeting at DePauw University. There are forty-eight high school science clubs currently affiliated with the Junior Academy. Science clubs are urged to contact the State Sponsor in order that the names of club sponsors and clubs may be kept up-to-date.

After expressing her appreciation to all who helped make the 1957 annual meeting a success, the president, Betty Jane Gough, adjourned the meeting.

MARGARET REYNOLDS,
Secretary

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

FALL 1957

	Town	*School and Club*	*Sponsor*
1.	Attica	H. S., Sci-Math (1949)	J. Claude Daugherty
2.	Bedford	H. S., Science (1951)	Elmer Wright
3.	Bloomington	H. S. National Scientific Honor Society (1931)	Harold A. Stewart
4.	Bloomington	University H. S., Jr. Academy (1938)	

	Town	*School and Club*	*Sponsor*
5.	Chesterton	H. S., Science (1954)	Robert McCord
6.	Clarksville	Our Lady of Providence H. S., Phy-Chem (1956)	
7.	Clayton	H. S., Jr. Academy (1951)	Howard C. Lewis
8.	Crawfordsville	H. S., Up-N-Atom (1950)	David Wells
9.	Edinburg	H. S., The Alchemists (1954)	S. C. Harrell
10.	Elkhart	H. S., Jr. Academy (1940)	Robert Mahan
11.	Fort Wayne	Central H. S., Biology (1940)	Iva Spangler
12.	Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club (1952)	Sister Anne Pauline
13.	Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
14.	Fort Wayne	North Side H. S., Nature (1936)	Vesta Thompson
15.	Fort Wayne	South Side H. S., Jr. Academy of Science (1956)	Robert Weber Don Weaver
16.	Gary	Calumet Twp. H. S., Science (1952)	
17.	Gary	Edison H. S. Beaker Breakers (1949)	Mrs. Martha B. Connor
18.	Gary	Lew Wallace H. S., Biology (1935)	Lola Lemon
19.	Gary	Lew Wallace H. S., Klub Kem (1941)	Mrs. Helen McKenzie
20.	Gary	Tolleston H. S., Biology (1952)	John Reidel Mr. Moore
21.	Gary	Tolleston H. S., Future Scientists of America (1949)	Arthur Kline
22.	Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
23.	Gas City	Mississinewa Joint H. S., Science (1936)	Roy McKee
24.	Griffith	H. S., Science (1953)	George M. Bunce
25.	Hamlet	H. S., Science (1954)	Lawrence Cushman
26.	Hammond	Morton Jr. H. S., Science (1949)	Nancy Lou Ritter
27.	Hobart	H. S., Science (1952)	Lola Stewart
28.	Indianapolis	Ladywood H. S., Guerin Science Club (1957)	Sister Mary Blanche
29.	Indianapolis	Shortridge H. S., Naturalists' Club (1947)	

	Town	*School and Club*	*Sponsor*
30.	Indianapolis	Shortridge H. S., Science (1931)	Mrs. Henrietta A. Parker
31.	Indianapolis	Technical H. S., Nature (1932)	Charles E. Russell
32.	Indianapolis	Howe H. S., Science (1949)	Jerry Motley
33.	Indianapolis	Washington H. S., Science (1931)	Mrs. Elizabeth H. Crider
34.	Lebanon	H. S., Jr. Explorers of Science (1953)	Helen E. Reed
35.	Madison	Shawe Memorial H. S., Science (1957)	Theodore A. Winkel
36.	Marion	Martin Boots Jr. H. S., Biology (1953)	John Clevenger
37.	Mishawaka	H. S. Science (1936)	Darl F. Wood
38.	New Albany	H. S., Science (1935)	Erwin Steinkamp
39.	New Castle	H. S., Science (1947)	Betty Jo Montag
40.	New Haven	H. S., Phi-Chi (1954)	Keith Hunnings
41.	Richmond	H. S., Science (1950)	Kathryn Coulter
42.	Rossville	H. S., Science (1954)	Martin Silverthorn
43.	Sandborn	H. S., Up and Atom (1954)	Paul D. Carter
44.	South Bend	Central H. S., Jr. Academy of Science (1939)	A. L. Smith V. C. Cripe
45.	South Bend	John Adams H. S., Adams Walton (1953)	Ernest Litweiler
46.	Sullivan	H. S., Camera (1939)	Ruth Hinkle
47.	Terre Haute	State H. S., Senior Science (1939)	Russell McDougal
48.	Valparaiso	H. S., Science (1931)	

NECROLOGY

WILL E. EDINGTON, DePauw University

ARTHUR FISHER BENTLEY

Freeport, Illinois — Paoli, Indiana
October 16, 1870 — May 21, 1957

Arthur Fisher Bentley at the time of his death was one of America's leading philosophers and humanists. He had spent the last forty-six years of his long life in contemplation and thought, living quietly on his estate near Paoli and occasionally publishing essays and books as the results of his work. He joined the Academy of Science in 1931 and frequently attended its meetings. One is not surprised at his interest in the Academy when one realizes the tremendous impact and influence of science on modern philosophic thought. The theory of evolution, genetic theory, relativity, quantum theory, postulational mathematics, indeterminism, nuclear theory, etc., have changed much of political, sociological and religious thought and practice during the past century. Fundamentally at every turn man is confronted with interpreting physical and mental phenomena with their possible multiple ambiguous relations and solutions, all apparently consistent with the known facts but not necessarily true to the facts. Scientists have been aware of this for several centuries and Arthur Bentley was deeply interested in fundamental thinking. He knew that consistency does not necessarily imply basic truth and he knew the necessity for careful definition and precise statement for basic understanding.

Arthur Bentley was born in Freeport, Illinois, on October 16, 1870, and died on May 21, 1957, in Paoli, Indiana. His father was a banker and a man of "unusual ability and intellectual candor." Young Bentley began his elementary education in Freeport and completed it in the Grand Island, Nebraska, schools. He then entered York College near Grand Island, but soon transferred to the University of Denver. After less than two years, ill health forced his return home where he worked temporarily in his father's bank. At the age of twenty he entered Johns Hopkins University and came under the influence of Dr. Richard T. Ely, the economist. When Ely transferred to the University of Wisconsin, Bentley changed his major interest from economics to sociology and graduated at Johns Hopkins in 1892 with the A.B. degree. He continued his study at that university, but spent the year 1893-94 at the University of Berlin and the University of Freiburg in Breslau. He received the Ph.D. at Johns Hopkins in 1895 and then became docent at the University of Chicago for six months, teaching sociology. At Chicago he became acquainted with John Dewey and there began a friendship that was to culminate in a joint philosophic work fifty years later.

Following his brief but important teaching experience Bentley took up newspaper work and served fifteen years as reporter and editorial writer on the *Chicago Times-Herald* and *Record-Herald*. From this he gained tremendous knowledge of, keen insight into and practical experience with human behavior and the attendant political and sociological problems. During this period, in 1908, he wrote his first book, "The Process of Government," which reflects the influence of Simmel, Gumplewicz and Durkheim in Europe and Dewey in America.

In 1910 Bentley gave up his newspaper work and the next year, at the age of forty, he settled on an estate just outside of Paoli, Indiana, where he spent most of the remaining forty-six years of his life extending and developing his philosophic thought. However, during World War I, 1917-19, he was chairman of the American Red Cross in Indiana. After the close of World War I the importance of Einstein's Relativity Theory became apparent in America following the experimental verification and agreement of Einstein's predicted results. The return of peace made available the works of Einstein, DeSitter, Eddington, Minkowski, Lorentz, and others. Bentley's contemplation of the four-dimensional world and its verified seeming contradictions of current explanations of phenomena based on the three-dimensional world, led to his second book, "*Relativity in Man and Society*," published in 1926. Further contemplation of the philosophic implications of Relativity and the postulational mathematical studies of Hilbert, Whitehead and Russell, and others, brought the appearance in 1932 of Bentley's "*Linguistic Analysis of Mathematics*".

Further study and development of his ideas led to the publication in 1935 of Bentley's book, "Behavior, Knowledge, Fact," and this work led to the collaboration of Bentley and John Dewey in the publication of eight joint papers, between 1945 and 1947, and their joint authorship, in 1949, of "Knowing and the Known". A number of his essays were brought together in 1954 in his last book, "Inquiry into Inquiries." A complete file of his manuscripts, published and unpublished, was given to Indiana University in 1953.

Because of Dr. Bentley's quiet career of writing and his modest disposition, his recognition and honors were belated. In 1953 he was made Honorary Vice-President of the "Conference on Methods in Philosophy and the Sciences." The American Humanist Association, in 1954, named him "Humanist of the Year." A Festschrift, "Life, Language, Law," a volume of essays contributed by such men as Sydney Ratner, P. W. Bridgman, George A. Lundburg, Sidney Hook, Adelbert Ames, Jr., and Felix Cohen, was published in 1956 in honor of Dr. Bentley. In its Epilogue appear the remarks made by Dr. Bentley at a dinner given in his honor in 1953 in Washington at the meeting of the American Political Science Association. At the Midwest Conference of the Humanist Association held in October, 1956, in Indianapolis, a symposium, The Transactional Approach to Human Behavior, was presented in honor of Dr. Bentley's 86th birthday, with Sydney Ratner, Richard W. Taylor and Harold T. Davis as speakers. This was Dr. Bentley's last public appearance and his last essay, "The Word Transaction," was read by Dr. Ratner.

The broad interest and depth of Dr. Bentley's thinking is evident from his membership in the American Association for the Advancement of Science, the Econometric Society, the American Mathematical Society, the Mathematical Association of America, the Association for Symbolic Logic, the Philosophy of Science Association, the American Humanist Association, and the Indiana Academy of Science. The Academy honored him as a fellow in 1945.

At the Indianapolis meeting in Indianapolis in 1956 Dr. Ratner stated that Bentley could be likened to a modern-day Socrates "because he is not a preacher, nor is he a moralizer. In his works Bentley has tried to show the world how to live on a better standard through a study of the mistakes of others."

HALBERT PLEASANT BYBEE

Rochester, Indiana	Austin, Texas
January 7, 1888	March 30, 1957

Geology played a prominent part in the early history of Indiana and has influenced Indiana economy. The coal, shale and limestone industries were and are still quite important, oil is less so. In the last century gas production was a factor. Since the time of the New Harmony experiment, the Owen brothers, Edward T. Cox, Ryland T. Brown, John C. Branner, Willis S. Blatchley, Edgar R. Cumings, and Clyde A. Malott were leaders in the study of Indiana geology. Indiana University has offered courses in geology since the Civil War days and DePauw, Earlham and Wabash also have been training many young geologists for a long time. One of Indiana University's outstanding graduates who earned his doctorate in geology was Halbert Pleasant Bybee who spent most of his professional life of over forty years in Texas.

Halbert Pleasant Bybee was born near Rochester, Indiana, on January 7, 1888. After completing his public school education he entered Rochester College, which existed at that time in Rochester, Indiana, and received the B.S. degree. He was Principal of the Township High School at Richland Center for a year and then taught science the next year in Clinton College, Clinton, Kentucky. In 1911 he entered Indiana University, received the A.B. in 1912, was made a Fellow in Geology and received the A.M. in 1913, followed by the Ph.D. in 1915. However, preceding his receiving the doctorate, in January, 1914, he became an instructor in geology at the University of Texas. There he served the University and the State for the rest of his life, with the exception of the four years, 1924-1929, while he was geologist for the Dixie Oil Company in San Angelo, Texas. He worked several summers as geologist with Oklahoma Geological Survey in Norman, Oklahoma.

Dr. Bybee's professional career was divided between teaching, consulting, and acting geologist in charge of the large land holdings owned by the University of Texas. At the University he was made Adjunct Professor of Geology in 1916 and an associate professor in 1920. Following his four years with the Dixie Oil Company he was appointed, in 1929, geologist in charge of University Lands with San Angelo as his headquarters. Eight years later he was transferred to Austin and made Geologist in charge of University Lands and Professor of Geology at the University. From 1954 until his death on March 30, 1957, he was Consulting Geologist on University Lands and Professor of Geology. He served as Chairman of the Geology Department from 1937 to 1941.

While a student at Indiana University Dr. Bybee joined the Academy of Science in 1912 and his first research was done in collaboration with Clyde A. Malott: "The Flood of 1913 in the Lower White River Region of Indiana," an article of 119 pages published as part of Indiana University Bulletin 12. Because of his consulting and administrative duties his time for research was restricted and he published only occasionally in the University of Texas Bulletins or the Bulletins of the American Association of Petroleum Geologists. He was author or joint author of more than a dozen papers.

Dr. Bybee was a Fellow in both the American Association for the Advancement of Science and the Geological Society of America. He was a member of the Geophysical Union, a life member and an honorary member of the American Association of Petroleum Geologists, a charter member and secretary for one year of the Southwestern Geological Society, and an Honorary Life Member of the Texas Academy of Science, and a member of the Society of Economic Paleontologists and Mineralogists. He was also a member of Sigma Xi and Sigma Gamma Epsilon, honorary geology and petroleum engineering fraternity.

As a public spirited citizen, he was deeply concerned with community welfare. A past president of the San Angelo Kiwanis Club, he became active in the Austin Kiwanis Club after leaving San Angelo and was a member of the Austin Chamber of Commerce. He was deeply interested in Boy Scout work and served for twenty-nine years as an Area Council member. He was also a Faculty sponsor at the University for the national scouting fraternity Alpha Phi Omega. In recognition of his service to Scouting he received the Silver Beaver Award, the highest award given to Area Council members.

Dr. Bybee was a deeply religious man who tried to live his religion. He served as deacon in the University Baptist Church and a long time member of the University Committee on Religious Life. Many a Texas student troubled by the seeming contradictions of scientific facts with religious teachings came to him for counsel and advice. The University availed itself of his experience and wisdom by appointing him a member of committees to set up an Institute of Latin-American Studies and to cooperate with the Department of Education in setting up a program of Teacher Education for Science Teachers. Dr. Bybee rendered genuine and lasting service to science, to his adopted State and to his fellow men.

JOSEPH BERNARD HERSHMAN

Rensselaer, Indiana	Marengo, Iowa
June 9, 1900	June 29, 1956

With the death of Joseph Bernard Hershman on June 29, 1956, two days after being mortally injured in an automobile accident near Marengo, Iowa, Indiana lost one of its leading educators who was at the zenith of his career. Dr. Hershman was a distinct Indiana product, born in Rensselaer on June 9, 1900, graduating from Valparaiso University with the B.S. degree in 1922, and receiving the M.A. in 1928 and the Ph.D. in 1932, in physics, from Indiana University. There he received much of his fundamental training in electronics and communications under Dr. R. R. Ramsey.

Following his graduation from Valparaiso University he remained at that institution for the next five years as instructor and head of the Department of Physics. He then went to Indiana University as an instructor and completed the work for the M.A. degree after which he accepted a position at Indiana State Teachers College as Assistant Professor and acting Head of the Department of Physics and Director of Broadcasting. Returning to Indiana University in 1931 as a graduate student and assistant in physics, he remained two years. In 1934 he accepted a position as Director of the Dodge Telegraph and Radio Institute and seven years later became its president. In 1944 he founded the Valparaiso Technical Institute and became its first president, which position he held at the time of his death.

In his founding of the Institute Dr. Hershman attempted to carry out his philosophy of education, insisting that the goals of the Institute were not those of the traditional engineering school but rather the training of specialists in electronics and communications. At the time of his death he had succeeded in building up a physical plant capable of handling efficiently 500 students and he had secured the cooperation of a number of leading firms such as International Business Machines, General Electric, Western Electric and the Sandia Corporation, in promotional work to get more students to train for careers in electronics and communications.

Dr. Hershman was civic minded and served for years as president of the Valparaiso Public Library Board and he was a past president of both the Valparaiso Park Board and the Valparaiso Chamber of Commerce. Professionally he held membership in the American Association for the Advancement of Science, the Institute of Radio Engineers, the American Association of Physics Teachers, the Society of Motion Picture and Television Engineers. The accident which caused his death occurred while he was returning from a meeting of the American Society of Engineering Education held in Ames, Iowa. In both 1954 and 1955 he was president of the National Council of Technical Schools. He was also a member of Sigma Xi and Alpha Epsilon professional societies. He first joined the Indiana Academy of Science in 1926 and published six papers in the *Proceedings* from 1927 to 1933. He was made a Fellow of the Academy in 1954. Besides being author of a number of scientific papers he published three books the last of which, "A Vocational Guide in Radio, Electronics and Television," appeared in 1953.

Dr. Hershman was recognized nationally by industry as an outstanding educator who had a broad understanding of the complex technological structure of American industry and who had made a great and most timely contribution in the training of young men to take their places effectively in a society whose progress and welfare is dependent on scientific and technological achievement. As one tangible recognition of his work the Board of Directors of the Valparaiso Technical Institute authorized as a memorial to Dr. Hershman the establishment of a scholarship, ultimately to be worth approximately $1,500, to be awarded annually to a high school senior ranking in the upper quarter of his class, majoring in mathematics and science, and interested in a technical education in electronics and communications. The death of Dr. Hershman is a great loss to this nation beset with the problem of securing trained scientists at a critical stage in our history.

JOHN HOBART HOSKINS

Carmel, Indiana	Cincinnati, Ohio
January 17, 1896	February 8, 1957

The Academy has been fortunate in having some outstanding out-of-state members and frequently they participate in Academy programs, making genuine scientific contributions to its work. Such a member was John Hobart Hoskins, a member of the Academy since 1927, who at the time of his death on February 8, 1957, had been Chairman of the Department of Biology and Bacteriology at the University of Cincinnati for over twenty-five years.

John Hobart Hoskins was born in Carmel, Indiana, on January 17, 1896, in a Quaker environment, and in due time entered Earlham College where his mother and older brother had been students before him. After receiving the A.B. degree in 1919 he immediately began graduate study in the University of Chicago and obtained the M.S. degree in 1920. The following two years he taught as Professor of Biology at Whittier College in California while he spent the summers of 1921 and 1922 in study at the Puget Sound Biological Station of the University of Washington. Granted a fellowship by the University of Chicago in 1922 he completed the work for the Ph.D. in botany and received the degree in 1924. The next year he spent in Europe as a National Research Council Fellow and upon his return in 1925 he was appointed Assistant Professor of Botany at the University of Cincinnati. He was promoted to associate professor in 1927 and to professor in 1937, but he had been appointed chairman of the department in 1931. He also spent the summers of 1925 to 1933 on the staff at the University of Notre Dame where he became associated with Father Julius Nieuwland and Theodor Just. Father Nieuwland had founded the *Midland Naturalist* in 1909 and in 1935 Dr. Hoskins became and remained an associate editor for twenty years, with his special interest in paleobotany.

Dr. Hoskins specialized in the study of fossil plants and his research on the coal ball, a type of plant petrification, gave information on the plant source of coal which led to the location of productive areas in coal fields. He was the author of approximately forty published research articles. Five of these articles appeared in the *Proceedings* of the Academy. He also presented three other papers to the Academy, one co-authored by Theodor Just. Although he was most widely known because of his work in paleobotany, he also did research in algology and plant morphology. He was particularly successful in training a number of younger paleobotanists. He built up a large collection of fossil plants at the University of Cincinnati and he collected a large number of reprints and other works on paleobotany for his own library. Following his death the University announced that the collection of fossil plants will hence-forth be known as the John Hobart Hoskins Memorial Herbarium, and his library, the gift of Mrs. Hoskins to the Department, will be housed with the collection. Also the J. H. Hoskins Memorial Fund contributed by friends and colleagues will be used for scholarships in paleobotany at the University.

Dr. Hoskins was a Fellow of the American Association for the Advancement of Science and an active member of the Botanical Society, twice served as chairman of its Paleobotanical Section. He was also a member of the American Institute of Biological Sciences, the Paleontological Society of America, the Phycological Society of America, the International Society of Plant Morphologists, and the Ohio, Illinois and Indiana Academies of Science. He was a past president of the Ohio Academy and a Fellow of the Indiana Academy. He was also a member of Phi Beta Kappa and Sigma Xi, and the Alpha Tau Omega social fraternity.

Besides his assistant editorship of the *American Midland Naturalist*, Dr. Hoskins was co-founder and assistant editor of *Lloydia*, a quarterly journal on biological science published by the Lloyd Library of Cincinnati. He was a member of the Lloyd Library Board and of the Cincinnati Country Day School Board. From 1946 to 1953 he was regional representative of Earlham College. He served in the Army in World War I from 1917 to 1919, and during World War II he was with the War Department, Training Branch, Quartermaster Corps, from 1943 to 1945.

Dr. Hoskins was well and favorably known by a large number of botanists in the Academy who recognized him as the excellent scientist that he was. In his own University he was known as a man of high ideals, a stimulating and inspiring teacher and "an exacting scholar with a vast store of knowledge, a sparkling personality with a ready wit and a man of deep human sympathy."

HENRY AUGUSTUS HUSTON

Damariscotta, Maine
April 20, 1858

Kew Gardens, New York
May 4, 1957

When the Indiana Academy of Science was founded in December, 1885, the charter membership roll was kept open for possibly a year and during that interval the charter membership became fixed at 69 members. The eldest member at that time, so far as can be determined, was Ryland T. Brown, born in 1807 and probably one of Indiana's most prominent scientists at the time. One of the younger charter members at the time, but by no means the youngest, was Henry Augustus Huston who was born on April 20, 1858, and whose death on May 4, 1957, brought to a close a period of 150 years, beginning at the time when Thomas Jefferson was President of the United States and extending to the presidency of Dwight Eisenhower, during which period a charter member of the Academy was alive.

Henry A. Huston was born in Damariscotta, Maine. He received the A.B. degree from Bowdoin College in 1879 and spent the following year there as an assistant in chemistry and physics. In 1880 he came to Lafayette, Indiana, as principal and science teacher in the high school, serving four years, during which time he received the M.A. degree at Bowdoin and the Analytical Chemist degree under Harvey W. Wiley at Purdue, both in 1882. He became Professor of Physics at Purdue in 1884 and assistant State Chemist. In 1888 he was made Professor of Agricultural Chemistry and served for fifteen years, during which time he helped to organize the Agricultural Experiment Station and was its Director in his last year at Purdue. He was also director of the State Weather Service in Indiana from 1884 to 1896. Leaving Purdue in 1903 he became manager of the West Office, Propaganda Department, German Kali Works, located in St. Louis for two years and then in Chicago for another five years. He transferred to Baltimore in 1910, as secretary, and then to New York in 1912. In 1919 he became technical manager in the U.S. Potash Syndicate, and four years later a consulting agricultural chemist, finally retiring in 1953 at the age of 95. In 1931 Purdue conferred the honorary Doctor of Science degree on him.

Dr. Huston throughout his long life retained a deep and loyal interest in Purdue. He served as president of the Purdue Alumni Association for nine years from 1895 to 1904. He returned frequently to the campus, particularly to attend the May Commencement exercises. In 1942 he was awarded the "sixty year" certificate and five years later he received the distinguished service award of the Purdue Alumni Association. In May of 1953 he rode in a helicopter from Camp Atterbury to the Purdue Airport, his first ride in a helicopter, to attend the gala week exercises. As the oldest living Purdue alumnus he enjoyed leading the gala week alumni parade. He was blessed with good health and he retained his vigor almost to the end of his life. He loved to travel. In 1925 he made a plant food survey in Italy and later made several other trips to Europe and he enjoyed going to South America, frequently making one or two trips a year. He owned an eighty-year-old flute which he carried with him on his foreign travels and he was often called on to play solos at ship's concerts. Shortly before his death he received an honorary membership in the Association of Musicians of Greater New York City.

In his younger days he did considerable research in agricultural chemistry and agronomy, especially while he was at Purdue. He published a number of papers, several of which appeared in the *Proceedings* of the Indiana Academy of Science in the early volumes, the last appearing in 1909. He was joint author of several papers. He held membership in the Association of Agricultural Chemists, the American Chemical Society, and the Society of Agronomists. He retained his interest in the Academy but he was unable to attend the Fiftieth Anniversary Meeting in 1934 when he was one of the fifteen living Charter Members to receive the fifty-year Recognition Certificates.

Dr. Huston's death breaks the last living tie with the early days of the Academy. Among the charter members were many outstanding scientists, nationally and internationally recognized: Butler, Jordan, the Coulters, Blatchley, Wiley, Mendenhall, Noyes, Arthur, Kirkwood, Branner, and others. Dr. Huston knew them all and has gone to join them.

WALTER ALBERT JAMIESON

Utica, New York	Traverse City, Michigan
May 10, 1890	June 5, 1957

While it is true that a large number of the most active members of the Academy come from the universities and colleges of the State, a number of the most productive members are associated with industry. The Academy has drawn five of its past presidents from Eli Lilly & Company and over the years members of that great industrial organization's scientific staff have contributed much to the scientific prestige of the Academy. One such member was Walter Albert Jamieson who was actively associated with Eli Lilly & Company thirty-two years before his retirement in 1949.

He was born on May 10, 1890, in Utica, New York, and received his preliminary education in the Utica schools. He graduated from the Utica Free Academy and then entered Trinity College, Hartford, Connecticut, received the A.B. degree in 1911 and thirty years later, had the honorary Sc.D. conferred on him. Following his graduation from Trinity he accepted employment as immunologist and bacteriologist in the Lederle Antitoxin Laboratories at Pearl River, New York, and six years later was appointed Assistant Director of the Biological Division of Eli Lilly & Company. In 1923 he was promoted to Director of the Biological Division (Production) and Biological Research which position he held until his retirement.

Dr. Jamieson directed research on bacterial antigens, viruses, toxins, antitoxins, germicides and biological preservatives. He introduced "Merthiolate" which is now accepted as a standard preservative for diphtheria prophylactics, serums for intravenous, intraspinal and intrathecal injections, and blood serum or plasma for transfusion work. During World War II he worked closely with the Army and Navy, had charge of the Blood Bank, was an advisor on the preservation of blood plasma supplied to Great Britain, and had charge of the accelerated research and production of vaccines for gas-gangrene, cholera, typhus, influenza and Japanese encephalitis. In his work with these dangerous substances he contracted typhus twice and was the victim of other serious laboratory induced infections. The results of his research, published in about 50 articles—a number of which were in collaboration with his colleagues at the Eli

Lilly & Company—appeared in such journals as the *Journal of Laboratory and Clinical Medicine, Proceedings of the Society of Experimental Biology and Medicine, American Journal of Hygiene, Journal of Immunology,* and others. He was joint author with Dr. H. M. Powell of ten papers that were published in the *Proceedings* of the Academy from 1931 to 1943.

In addition to being a member of such organizations as the Society of American Bacteriologists, American Association of Immunologists, and the Canadian Health Association, he was also a charter member of the Electron Microscope Society of America and a Fellow of the American Association for the Advancement of Science, American Public Health Association, Royal Society of Tropical Medicine and Hygiene and the Indiana Academy of Science, and a trustee of the American Foundation for Tropical Medicine. He was chairman at various times and secretary of the Biological Section of the American Drug Manufacturers Association and was asked to speak at the 1957 meeting of the Section. He held membership in the Indianapolis Chamber of Commerce and the Indianapolis Athletic Club and he belonged to the Alpha Chi Rho social fraternity. During World War II he was a member of the Biological Subcommittee of the Drug Resources Advisory Committee of the Army and Navy Munitions Board and of the Gas-Gangrene Antitoxin Producers Industry Advisory Committee of the War Production Board.

Dr. Jamieson was a deeply religious man and a very active member of the Episcopal Church. Besides service in the vestry of local Indianapolis churches he was Trustee of the Indianapolis Diocese for twenty years. As Treasurer of the Indianapolis Episcopal Diocese from 1941 to 1957 he visted all missions and parishes throughout Indiana each year and thus became well known. He was also Secretary of the Diocese from 1953 to 1957 and was a delegate to the last general convention held in 1955 in Hawaii. Since his death a number of churches in the State have set up memorials dedicated to his memory and the swimming pool in the church camp in Brown County has been named after him. Besides his church work he was Founder of the Indianapolis Chapter of the National Society for the Prevention of Blindness and served as its secretary and a member of its Executive Board the last four years of his life.

Following his retirement in 1949 Dr. Jamieson made his home at Green Braes Orchard outside of Indianapolis. When not busy with his church work he pursued several hobbies such as making a collection of air mail stamps, experimenting with chemical water culture of vegetables and working with boys. He had a summer home, Loch Hame, on Torch Lake near Alden, Michigan, where he had a greenhouse in which he carried on experimental work the last eight years of his life. He also became interested in the South Torch Lake Recreational Association at Alden, helping to organize baseball teams for boys and officiating as an umpire on occasion. In Boy Scout work in Indiana he was a member of the New Augusta Pack Committee the last year he lived.

With the death of Dr. Jamieson on June 5, 1957, in a Traverse City, Michigan, hospital, following a coronary attack, Indiana lost a fine citizen, a sincere churchman, and an excellent scientist and administrator.

HENRY REIST KRAYBILL

Mt. Joy, Pennsylvania	Chicago, Illinois
May 1, 1891	September 30, 1956

One of the most productive research scientists of this century to be associated with the Indiana Academy of Science was Henry Reist Kraybill. He was author or joint author of nearly 150 research papers, bulletins and reports, published in more than 25 leading scientific and trade journals, in agricultural chemistry, chemistry, botany, food and meat preservation. He was also joint author of Bulletins or Reports issued by Agricultural Experiment Stations in four states: Pennsylvania, Oregon, New Hampshire and Indiana. He and his associates were also granted 13 patents based on research done under his supervision. Not only was he a splendid researcher but he also had administrative ability of high order, which received recognition in his university, industrial and professional appointments. At the time of his death in Chicago on September 30, 1956, he was Vice President and Director of Research of the American Meat Institute Foundation, Director of the Department of Scientific Research of the American Meat Institute, and professorial lecturer in the Department of Biochemistry of the University of Chicago.

He was born on May 1, 1891, in East Donegal Township, Lancaster County, Pennsylvania, near Mt. Joy. In 1909 he entered Pennsylvania State College and graduated in 1913 with a B.S. degree in agricultural chemistry. After graduation, while still retaining his connection with Penn State as assistant chemist and instructor in agricultural chemistry, he completed the requirements at the University of Chicago for the M.S. degree in 1915 and for the Ph.D. in plant biochemistry in 1917. He was a teaching fellow at the University of Chicago during the year 1916-1917. His doctoral thesis was a joint research problem with E. J. Kraus, of the Oregon State Agricultural Station, in the study of the physiology of the tomato plant, and it has since become a classic in plant physiology that made the names of Kraybill and Kraus well known to European scientists working in that field. Following the granting of his doctorate he returned to Penn State as an assistant physiologist, Bureau of Plant Industry, U. S. Department of Agriculture, and two years later he was appointed Professor and Head of the Department of Agricultural Chemistry at the University of New Hampshire, and also State Chemist. In 1924 he went to the Boyce Thompson Institute for Plant Research as a biochemist and two years later he accepted a professorship in agricultural chemistry at Purdue University together with the appointment as Indiana State Chemist and Seed Commissioner.

While at New Hampshire Dr. Kraybill became interested in plant viruses, particularly a tomato virus, and a series of papers followed during the next ten years on the results of the filtration, inoculation and purification of a tomato virus as well as the properties of the virus. He worked out methods for a high purification of the virus, determined accurately its activity at certain acidity and alkalinity levels, ascertained the conditions under which the virus could be stored, and determined its properties to pass certain filters which are known to remove bacteria. "Had Dr. Kraybill taken this work a step further and crystallized the virus, he would have accomplished essentially what Dr. Stanley did several years later in working with the tobacco mosaic virus. Dr. Stanley was awarded the Nobel Prize for his work."

Dr. Kraybill was promoted to the headship of the Department of Agricultural Chemistry at Purdue in 1934. He remained at Purdue fifteen years during which time much of his research was devoted to the study of plant oils, especially soy bean oil and its utilization. He also worked on nutrition studies and he with two colleagues discovered the symptoms of trytophan deficiency in the white rat, which is believed to be the first description of an amino acid deficiency in animals. Several patents were granted him and associates working under the Purdue Research Foundation.

In 1941 he became Director of the Department of Scientific Research of the American Meat Institute and he also became professorial lecturer in biochemistry at the University of Chicago that same year. He became Director of Research and Education of the American Meat Institute Foundation in 1947 and was made a Vice President in 1955.

During World War II Dr. Kraybill and his colleagues worked with considerable success on the problems of dehydrating and compressing meat because of the limited shipping space in cargo vessels and the shipping losses by submarines. Following the war their attention was concentrated on antioxidants in foods whereby rancidity in fats would be retarded and the storage life of foods would be extended. A number of interesting effects of irradiation in the sterilization of foods were discovered and put to practical use.

In 1949 as consultant to the Chief of the Economics Cooperative Administration Dr. Kraybill was sent to Greece on a mission.

Dr. Kraybill was a member of 15 scientific societies and eight honor fraternities and technical clubs. He was a Fellow of the American Association for the Advancement of Science, the American Institute of Chemists and the Indiana Academy of Science. From 1936 to 1938 he was chairman of the division of agricultural and food chemistry of the American Chemical Society. He served as president of both the Association of Official Agricultural Chemists and the American Association of Feed Control Officials in 1932, and of the American Society of Plant Pathologists in 1938.

Dr. Kraybill was stricken with a serious illness toward the end of 1955 and seemingly recovered but passed away on September 30, 1956. However, before his death, Purdue University, on June 3, 1956, conferred the honorary Sc.D. on him "in recognition of his devoted service to this (Purdue) university and for his distinctive achievements as a scientist, teacher and administrator whose contribution to biochemistry, plant production, and food processing have advanced the science of agriculture with resulting benefit to all people." And on September 20, 1956, he was informed that the 1956 Dodge and Olcott Award had been conferred on him "in recognition of scientific accomplishments of outstanding and lasting significance in connection with the processing of meat and meat products."

Quiet and unassuming, but noted for his fearless but kind integrity, he sought little recognition for himself and was always ready to help others. An excellent teacher and administrator, a stimulating scientist with vision and imagination, a churchman with a deep sense of responsibility to humanity, and a man devoted to his family and friends, Henry Reist Kraybill left the world better than he found it. He was a truly outstanding man and scientist.

PHILIP LUGINBILL

Columbus Grove, Ohio	Lafayette, Indiana
October 16, 1886	December 16, 1956

There was a time in this country when research was carried on largely as an individual matter, and individuals were associated with and credited with the results. The principal exceptions to this were in the Federal agencies like the U.S. Department of Agriculture where the problems were too broad and comprehensive to be solved by individual effort and required team work. Once the universities were the principal seat of research but with the development of the great industrial research laboratories, the financing of great research projects by Foundations, and the tremendous growth of Federal research programs, teamwork is the necessary basis for success and joint credit to a group rather than to individuals is becoming the rule rather than the exception. The complex problems in health, old age, economics, industry, agriculture, defense, et cetera, require the pooled efforts of many specialists. The common good demands the ultimate in unselfish cooperation if the problems are to be solved. Individuals will still stand out but their success will depend on the work of their colleagues which the individual uses to deduce his findings.

The success of modern agriculture in the United States is due to the pooled efforts of thousands of chemists, botanists, zoologists, inventors, industrialists and farmers—theoretical and applied experimenters, with time as an essential element. Philip Luginbill was one of that great team of entomologists of the Department of Agriculture. He devoted forty years of his life to the study of cereal and forage crop insects. He was the author of many research papers on economic entomology and the classification of insects.

Philip Luginbill was born at Columbus Grove, Ohio, on October 16, 1886. Following the usual public school education he taught in the public schools of Ohio for two years, 1904 to 1906, and then entered Ohio State University where he received the B.S. in Agriculture in 1910. He immediately entered government service in the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, receiving his first appointment through the efforts of John J. Davis, who had just come to Purdue University to take charge of the Cereal and Forage Insect Laboratory at the University, and he and Professor Davis remained lifelong friends. Dr. Luginbill was sent two years later to Columbia, South Carolina, to take charge of the Federal insect laboratory affiliated with the University of South Carolina. During his stay of eight years at Columbia he completed the work for the M.A. degree in 1917 at the University. In 1920 he was transferred to Monroe, Michigan, to take charge of research on the corn borer. While in Monroe he completed the requirements for the Ph.D. in biology at George Washington University and received the degree in 1924. In 1933 he returned to Lafayette as Senior Entomologist in charge of the Federal research laboratory in entomology with his offices in the Federal Building but affiliated with Purdue. He retired from government service in 1950.

Dr. Luginbill was a Fellow in the American Association for the Advancement of Science, which he joined in 1910, and of the Entomology Society of America. He was also a member of the American Association for Economic Entomology, and the South Carolina, Ohio and Indiana Academies of Science.

After his retirement he continued to live in West Lafayette and at the time of his death he had just completed a two year term as president of Lafayette Civil Service Club. An active churchman he had served the Central Presbyterian Church in Lafayette as superintendent of its Sunday church school for twenty years, and he had also participated in the church's Senior Fellowship workshop.

Dr. Luginbill was a hard and conscientious worker, thoroughly interested in his field of science, and a faithful servant of his country. It is impossible to estimate how much the farmers of the Middle West owe to his efforts in controlling the insect pests. He left an enviable record as a fine entomologist, an excellent civil servant, and a good citizen who worked for the welfare of humanity, both youth and adult.

DANIEL CHARLES O'GRADY

Depot Harbor, Ontario, Canada	South Bend, Indiana
January 7, 1905	May 7, 1957

With the death of Daniel Charles O'Grady, following a heart attack on May 7, 1957, the Academy lost for this year its second prominent philosopher and psychologist. He was born in Depot Harbor, Ontario, Canada, on January 7, 1905. He received the Bachelor of Philosophy degree at the University of Ottawa in 1924, the A.M. degree at Catholic University of America, Washington, D. C., in 1926 and the Ph.D. in Philosophy at the University of Ottawa in 1927.

He joined the Faculty at Notre Dame in 1926 as an instructor in philosophy, was promoted to assistant professor in 1930, associate professor in 1937 and to a professorship in 1940. Granted a leave by the University in 1942, he entered the military service as a private soldier, served as a clinical psychologist and personnel consultant on the staff of the Adjutant General School at Fort Oglethorpe, Georgia, and was discharged in 1945 with the rank of captain. After the war, in addition to his work at Notre Dame, he lectured in the Indiana University Extension Center at South Bend. He had served as a psychological consultant at the Northern Indiana Children's Hospital since 1950, and at the Beatty Memorial Hospital, Westville, Indiana, since 1951. He became a citizen of the United States some years ago.

Dr. O'Grady was coauthor with the Rev. Charles C. Miltner, C.S.C., former Dean of the College of Arts and Letters at Notre Dame and now President of the University of Portland, Oregon, of an outstanding book, "Introduction to Metaphysics," published in 1930, which is widely used as a textbook in many colleges both in America and England. He also published in 1932, another book, "Cosmology: A Cross Section," in the preparation of which he studied for some time at the Dominion Astronomical Observatory in Ottawa. He was also author of 23 articles and essays published in such journals as the *Proceedings of the American Catholic Philosophical Association, The New Scholasticism, The Thomist, Encyclopedia of Religion, America, The Catholic School Journal* and the *University of Ottawa Review.* He also wrote about 50 book reviews which appeared mostly in the *University of Ottawa Review* and *The New Scholasticism.* In 1946 he was appointed associate editor of *The New Scholasticism.*

He was a member of the American Association for the Advancement of Science, the Royal Astronomical Society of Canada, the Medieval Academy of America and the American Catholic Philosophical Association. Also as a member of the Indiana Psychological Association he had served at one time as its secretary and treasurer. Dr. O'Grady joined the Indiana Academy of Science in 1954 and consequently was not well known to many members of the Academy. However it is deeply to be regretted that this able teacher, philosopher and psychologist was stricken at the height of his powers.

GUY STANTZ

Coal City, Indiana — Colorado Springs, Colorado
October 31, 1884 — June 22, 1955

One of the big problems after retirement is having something to do, particularly if one has led an active life. Guy Stantz who at the time of his retirement was Principal of Gerstmeyer Technical High School in Terre Haute, Indiana, solved that problem by taking up hobbies requiring some knowledge of botany, geology, anthropology and travel. These interests led him to join the Indiana Academy of Science in 1952 when he was 68 years old. He was on a vacation trip in Colorado when he died suddenly on June 22, 1955, of a heart attack in Colorado Springs.

Guy Stantz was born on October 31, 1884, in a log cabin in Owen County near Coal City, Indiana. He attended the district schools and graduated from Worthington High School, after which, in 1905, he began teaching in the district schools of Greene County. This was about the time that the state began to require at least one quarter of professional training and since many of the country schools of that day were on a six or seven months yearly term, teachers flocked to the State Normal School in Terre Haute for the spring and summer quarters, at times tripling the enrollment as compared to the normal fall and winter quarters. Mr. Stantz began his professional training in what was then called manual training, now industrial arts, at the Normal. He acquired a certain prominence while there because of his athletic ability as a dash man, hurdler, pole vaulter and broad jumper, and he served on the Faculty-Student Athletic Board in 1908 and 1909. He became a teacher of mathematics and industrial arts in 1909 in Salem, Indiana, remaining one year, and spent the next two years teaching science and industrial arts and coaching in the Centralia, Illinois, High School. In 1912 he returned to Terre Haute as teacher of industrial arts in the high school. Five years later he accepted a similar position in Cleveland Heights, Ohio. He returned again to Terre Haute in 1919 as head of the department of industrial arts and athletic coach in Wiley High School. In 1923 he was appointed Principal of the Boys Vocational School and supervisor of industrial arts and director of vocational education, and during the next two years he developed the Vocational School into a technical high school called Gerstmeyer Technical High School. He continued as Principal of this school until his retirement in June, 1953.

While Mr. Stantz taught steadily year after year he nevertheless succeeded in graduating with the B.S. degree in 1927 from the Indiana State Normal School, which name by legislative action in 1929 was changed to Indiana State Teachers College. He continued with graduate study at Indiana University and received the M.S. degree in 1929.

Mr. Stantz was a far-seeing educator and principal. In Gerstmeyer High School he set up a program making vocational training a part of the regular high school curriculum and he pioneered the guidance movement in Terre Haute. His school had the first Home Room program in Indiana, and in addition to the day school he operated a night school for adults which met a real educational need.

Professionally he was a member of the local, State and National educational associations, the Vocational Association, the Vocational Guidance Association, the Association of Vocational School Principals, the Wabash Valley Industrial Education Club, and Phi Delta Kappa, education fraternity. In 1929 he was president of the Indiana Vocational Directors Association.

He was civic minded and interested in all phases of youth work. As a member of the Kiwanis, service club, he enlisted its active support in the Boy and Girl Scouts, particularly in the development of their camps. He was a long time member of the Wabash Valley Area Boy Scout Council and in recognition of his long and faithful service he received, in 1947, the Silver Beaver Award, the highest honor conferred on a volunteer worker in the Area. One of the two lakes in the Area Camp Krietenstein was named Stantz Lake in his honor.

Guy Stantz was a lover of nature and an out-door man. He was interested in conservation and the development of out-of-doors recreation centers. He was active in the Isaac Walton League and in the National Park Association, and was President of the Dobbs Memorial Forest.

He was a practical Christian. He had no children of his own but on the death of his wife's brother he and Mrs. Stantz willingly and faithfully reared and educated the five children who were left.

Educator, administrator, civic leader, and devoted friend of youth, Guy Stantz lived a full and fruitful life.

SISTER CARMELLA WELTE

Terre Haute, Indiana — Chicago, Illinois
January 2, 1890 — January 15, 1956

Church supported schools have played a very important part in our history, both in the nation and in this state. At the time the Academy was founded a church school, DePauw, was the largest school in the state, and at the present time another church school, Notre Dame, is the third largest university in the state. Science, being nonsectarian, provides an excellent means for teachers from all the colleges and high schools of the state to get together voluntarily for a profitable, valuable and friendly exchange of ideas and information. And for many years the Academy has counted as members a number of Sisters from the Catholic colleges for women as well as from some of the parochial high schools associated with the Junior Academy, and frequently papers are presented and research findings are discussed by these dedicated women. Sister Carmella Welte had been a member of the Academy thirty-one years and as a member of the teaching staff of Saint Mary of the Woods College she had frequently attended Academy meetings.

Sister Carmella Welte was born Ada Welte, on January 2, 1890, in Terre Haute, Indiana. She received her early education in the public schools of Terre Haute, entered the Indiana State Normal School, now the Indiana State Teachers College, and graduated in 1913 with the A.B. degree. She spent the next two years teaching German in King Crawford Classical School in Terre Haute and then returned to the Normal School for a year of post-graduate study. During the two years from 1916-18, she taught German in Bartholomew County and then taught Latin and English for a year in Fontanet High School in Vigo County. In 1919 she entered the convent of the Sisters of Providence at Saint Mary of the Woods near Terre Haute.

Her first year of study at Saint Mary of the Woods College was devoted to English and she received the A.B. in 1920 from the College together with a teacher's certificate. She then entered Purdue for six months of study in bacteriology, biology and chemistry after which she returned to Saint Mary of the Woods College and taught biology and botany. She spent the year 1922-23 and the summers of 1923, 1924 and 1925 at Indiana University and received the A.M. degree in 1925. She continued teaching biology at the College until 1945 with the exception of the year 1933-34 when she returned to Indiana University for further study.

In 1945 symptoms of heart trouble became apparent and with the hopes of improving her health she was assigned lighter employment in a smaller school. She spent the next three years in Marywood School in Evanston, Illinois, and the following year at St. John's Academy in Indianapolis. Finally, to lighten her work still more, she was made a member of the library staff of Providence High School in Chicago, and she was on duty there when stricken with a sudden heart attack that ended her life on January 15, 1956.

Sister Carmella was a devoted teacher of biology who taught carefully and painstakingly. She was deeply interested in the physical and spiritual welfare of her students as well as in their intellectual and scientific growth. Among the Sisters of her Community she was recognized and highly regarded as a faithful and conscientious member of the Order, who had a generous and universal charity for all and being willing to help anyone in need.

PRESIDENTIAL ADDRESS

UNDERGRADUATE CURRICULA IN BIOLOGY

Willis H. Johnson, Wabash College

During the past year it was my privilege to participate in a Conference on Undergraduate Curricula in Biology, sponsored by the Committee on Educational Policies of the Division of Biology and Agriculture of the National Research Council. Since I am convinced that the problems considered in this conference should be of interest, not only to biologists, but to all involved in undergraduate education, I want to present to you a summary of the work of this conference.

First I would like to say a few words about the background of the Conference, about the objectives and organization and about the participants.

In 1953 the Division of Biology and Agriculture held a Conference on Biological Education. At the conclusion this recommendation was made:

> "In view of the rapid development of the biological sciences, it is desirable that educational and instructional objectives and practices be subject to continuous and concerted study. Be it therefore resolved that a policy committee be established within the structure of the Division of Biology and Agriculture of the National Research Council, to confer with and advise those individuals and organizations that are most intimately concerned with biological education in its many facets as to the present and prospective demands upon, and needs of, the biological sciences."(1)

In 1954, Dr. Paul Weiss, Chairman of the Biology Council, appointed the Committee on Educational Policies with Dr. Howard Phillips as Chairman. Since that time the committee, through seven subcommittees, has been concerned with problems at all educational levels, from elementary and secondary to graduate and professional, and in all branches of biology, basic and applied.

The conference on undergraduate curricula was one of the results of the activities of the subcommittee on college education. Dr. Thomas Hall has served as chairman of this subcommittee. One of the first things which this subcommittee did was to write to some 500 biologists, asking them to indicate what they considered to be the most important problems in connection with college education in biology and what they would propose as solutions to the problems. A rather large number of problems were indicated and the subcommittee selected several of these for study and recommendations. As a result of this, a publication of the subcommittee "Improving College Biology Teaching"(2) will soon be ready for distribution.

In the list of suggested problems the need for a thorough, biology-wide appraisal of basic principles to guide selection of content and choice of organization for undergraduate courses and curricula stood very high. Many of those who replied stated that college programs often fail to keep pace with the evolution of the biological sciences and the changing needs of students and society. Many also emphasized the importance of coordinated consideration involving the whole range of biological disciplines, pointing out that past conferences and studies have generally dealt with separate fields, single institutions, or isolated aspects of a curricular problem.

The Subcommittee proposed to the parent committee that a conference be held on undergraduate curricula which would include representatives of all fields of biology. As a result the Committee on Educational Policies, supported by a grant from NSF, invited a broadly representative group of biologists to meet and consider curricular problems.

Those invited were:

Principal Participants

Willis H. Johnson, Chairman, Department of Biology, Wabash College, Crawfordsville, Indiana, *Chairman*

Marston Bates, Professor, Department of Zoology, University of Michigan, Ann Arbor, Michigan

Wendell H. Bragonier, Chairman, Department of Botany and Plant Pathology, Iowa State College, Ames, Iowa[2]

Julius H. Comroe, Jr., Professor, Department of Physiology and Pharmacology, Graduate School of Medicine, University of Pennsylvania, Philadelphia 4, Pennsylvania

Lincoln Constance, Dean, College of Letters and Science, University of California, Berkeley 4, California

Harriet B. Creighton, Professor, Department of Botany and Bacteriology, Wellesley College, Wellesly 81, Massachusetts

Donald R. Griffin, Professor of Zoology, Biological Laboratories, Harvard University, Cambridge 38, Massachusetts[2]

I. C. Gunsalus, Professor, Department of Biochemistry, University of Illinois, Urbana, Illinois

James H. Hilton, President, Iowa State College, Ames, Iowa[1]

George W. Kidder, Professor, Department of Biology, Amherst College, Amherst, Massachusetts

Chester A. Lawson, Head, Department of Natural Sciences, Michigan State University, East Lansing, Michigan

John A. Moore, Professor, Department of Zoology, Columbia University, New York 27, New York

Henry J. Oosting, Chairman, Department of Botany, Duke University, Durham, North Carolina

Robert B. Platt, Professor, Department of Biology, Emory University, Emory University, Georgia

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[1] Attended December meeting only.

[2] Attended April meeting only.

Alfred S. Romer, Director, Museum of Comparative Zoology, Harvard University, Cambridge 38, Massachusetts

I. W. Sizer, Head, Department of Biology, Massachusetts Institute of Technology, Cambridge 39, Massachusetts

Frits W. Went, Professor, Department of Biology, California Institute of Technology, Pasadena, California

Other Participants

Division of Biology and Agriculture, National Academy of Sciences—National Research Council

L. A. Maynard, Professor of Nutrition and Biochemistry Emeritus, Cornell University, *Chairman*[1]

Frank L. Campbell, *Executive Secretary*[1]

Paul Weiss, Head, Laboratory of Developmental Biology, Rockefeller Institute for Medical Research, 66th Street and York Avenue, New York 21, New York. Past Chairman of the Division of Biology and Agriculture; Chairman of the Biology Council 1954-57

Russell B. Stevens, Professor and Executive Officer, Department of Botany, George Washington University, Washington, D. C.; Executive Secretary of the Biology Council, 1954-57.

Committee on Educational Policies

Howard M. Phillips, Dean, The Graduate School, Emory University, Emory University, Georgia, *Chairman*

Clyde E. Bailey, Dean Emeritus, Institute of Agriculture, University of Minnesota, St. Paul 1, Minnesota

John A. Behnke, Vice President and Science Editor, The Ronald Press Company, 15 East 26th Street, New York 19, New York

Claude S. Chadwick, Head, Department of Biology, George Peabody College for Teachers, Nashville 5, Tennessee

Thomas S. Hall, Dean, College of Liberal Arts, Washington University, St. Louis 5, Missouri

Milton O. Lee, Federation Secretary, Federation of American Societies for Experimental Biology, 9650 Wisconsin Avenue, Washington 14, D. C.

Theophilus S. Painter, Professor, Department of Zoology, University of Texas, Austin 12, Texas

Richard E. Paulson, *Executive Secretary*

Subcommittee on College Education of the Committee on Educational Policies

Thomas S. Hall, *Chairman*

Benson E. Ginsburg, Associate Dean of the College, University of Chicago, Chicago 37, Illinois (during 1957-8, Center for Advanced Study in the Behavioral Sciences, 202 Junipero Serra Boulevard, Stanford, California)

Victor A. Greulach, Professor, Department of Botany, University of North Carolina, Chapel Hill, North Carolina

Willis H. Johnson, Chairman, Department of Biology, Wabash College, Crawfordsville, Indiana

John R. Raper, Professor of Botany, Biological Laboratories, Harvard University, Cambridge 38, Massachusetts[2]

National Science Foundation

Donald B. Anderson, Dean, Graduate School, North Carolina State College, Raleigh, North Carolina; Program Director for Education in the Sciences, National Science Foundation, 1956-57.

The Conference held two sessions, the first in Washington, December 8 and 9 and the second at Chapel Hill, April 1-4.

The Conference dealt with two interrelated problems: biology in the college, and the college in the training of biologists. Before it could attempt to deal with these problems the Conference had first to reach agreement on the general objectives of college education. The Conference took the stand that the primary purpose of the undergraduate college is to develop literate, broadly informed, and responsible citizens. In this they were concerned with what every educated person should learn about the life sciences and with the general literacy of prospective biologists. The conference further agreed that the college has a second purpose: to help the student acquire a firm grounding in the broad field of learning which includes his ultimate occupational goal. It was the concensus of the conference that no more than half of the total undergraduate program, for a major in biology, should be devoted to biological and supporting science courses, with the remainder alloted to courses in the humanities and social sciences.

Discussions at both meetings were focussed upon three main questions related to the three principal levels with which undergraduate education is concerned.

First: Should an acquaintance with biological sciences be expected of all college graduates? What objectives, characteristics, and content are recommended for introductory college courses in biology?

Second: Beyond the introductory program, what core of biological and other knowledge can be recommended for all future biologists irrespective of their eventual field of specialization?

Third: Beyond the introductory program and the common core for all prospective biologists, what is the role of the undergraduate program in preparing students for different biological specialties?

At the Washington session the participants were divided into 4 groups of 7 or 8 persons each for the consideration of questions 1 and 2 with a variety of interests represented in each group. For question 3 they met as botanists, zoologists, medical biologists, agricultural biologists, and biologists interested in teacher training. Each group had a recorder who presented the results of the group discussion to the conference as a whole.

Following the Washington meeting the subcommittee met and prepared a digest of that meeting. This digest showed the areas of agreement and also indicated the recommendations that were made by one, or two, or three of the groups on both questions 1 and 2. This, then, served as a guide for the discussions at Chapel Hill.

In this interim between the two sessions the conferees had an opportunity to confer with their colleagues on the questions which had been raised at the Washington session.

At Chapel Hill the conferees met again in 4 small groups to consider questions 1 and 2 with the digest of the Washington meeting as a guide. The groups were mixed; i.e., the participants found themselves with persons they had not met with in small group in Washington. For question 3 the participants met in two different ways at Chapel Hill. They met first as botanists, zoologists, etc., as in Washington, and then they met in groups according to Areas of Inquiry according to the system developed in the Division of Biology and Agriculture which is familiar to many biologists as it is used in a modified form by the National Science Foundation.

These groups were:

- Molecular and Cellular Biology
- Regulatory Biology
- Developmental Biology
- Group and Environmental Biology
- Genetic Biology
- Systematic and Evolutionary Biology

The recorder in each small group (there were four for No. 1, four for No. 2, and eleven for No. 3) presented his report to the Conference as a whole for discussion. Following the discussion each report was adopted by the conference as a whole. These reports with only minor editorial changes will make up a large part of the Conference Report which will soon be ready for distribution as a National Academy—National Research Council Publication.(3) I am sure that most of you will say, after reading the document, that there was an amazing degree of agreement in the different reports on a given question.

The Committee on Educational Policies, in setting up the Conference stated this as the objective "to develop guiding principles and useful model programs for organizing undergraduate instruction in biology." The Committee further stated "No single conference can resolve all questions, nor can any small group, however, distinguished, speak for all biologists. The Committee believes, however, that the Conference can significantly promote what must be a continuing process of study, review and modification of programs, helping to insure that biological education evolves at a pace commensurate with the advancement of the science it serves." In other words it was the hope that the recommendations of the Conference may prove of value to departments and institutions which are in the process, or may in the future undertake, curricular revisions.

Question I

Should an acquaintance with the biological sciences be expected of all college graduates? What objectives, characteristics and content are recommended for introductory college courses in biology?

At the concluding session on April 4, 1957, the Conference unanimously adopted the following resolution:

> "We believe that all educated persons should obtain a knowledge and appreciation of the biological sciences. This may be attained through good precollege courses, the kind of introductory college courses in biology outlined in the report of the Conference, or self study. Biologists should make every effort to maximize opportunities and motivation for young people to acquire at least this much understanding of biology."

All but four of the participants further recommended:

> "This basic knowledge of biology should be obtained through formal courses in high school or college."

The Conference considered and voted on this resolution as a way of formally affirming the view that the biological sciences, being an important component of our culture, deserve to be appropriately represented in the background of every well-educated person. Colleges and universities share responsibility for supplying this understanding with the secondary schools.

The nature of the world as it appears to biological scholars, the history of scientific thought in this area, methods of investigation used, current conclusions and their application and implication are essential aspects of a liberal education and necessary foundations for other curricular areas. Such knowledge can only be obtained through a study of biology. Once mastered it has essential interconnection with many aspects of the social sciences, philosophy, medicine and agriculture, esthetics, and other humanistic desciplines. Although intimately related to the physical sciences on which it draws, biology is sufficiently unique both in subject matter and methodology to warrant separate study. It cannot be considered merely as an example of scientific achievement for which a non-biological science can provide equivalent knowledge. Both the physical and biological sciences should, therefore, be included in the student's curriculum. If possible the introduction to the physical sciences, together with mathematics, should precede biology. However, general college courses in biology should not be postponed on this account. Adequate high school preparation in mathematics, physics, and chemistry can meet the needs as regards the college general biology course.

The sense in which an introductory program in biology was recommended as liberal education for everyone looks toward a course (or courses) in which selected major concepts of biology are examined in the light of their history (including the reasoning and evidence on which they are based) and related to the data which they help organize. Such a program should have equal value to the potential biology major and the nonbiologists alike. It should be challenging in intellectual content and good enough in substance to serve as prerequisite for more specialized courses for the major.

OBJECTIVES

Despite differences in wording and emphasis, the statements of objectives produced by the four different groups were remarkably similar. The statement of one group is as follows:

1. To convey the nature of the scientific process and the methods of investigation as exemplified by the life sciences, including the history of biological ideas and their relation to other historical ideas.

2. To develop an understanding of and interest in the nature of organisms through an understanding of important basic biological concepts, illustrated and supported by a suitable, carefully limited selection of examples. All the content and vocabulary of the course, whether presented in lecture, laboratory or field, should be selected with these goals in mind.

3. To develop an appreciation of the contributions of the biological sciences to man's understanding of the world he lives in, his material progress and his appreciation of the order, harmony and beauty of the world.

4. To present biology as an open and growing field by including modern developments, some of which have arisen from the concepts and methods of biology and some of which have come from the physical sciences and mathematics.

5. To provide an opportunity for actual experience with organisms in applying the techniques and methods of the biological sciences, including observation, comparison, formulation of hypotheses, experimentation, analysis, correlation and evaluation of data, and drawing of conclusions.

6. To exemplify the ways in which attempts to solve practical problems led to the development of theoretical concepts and, also, the ways in which basic research has contributed to the solution of practical problems.

7. To encourage independence in the use of the library as a source of ideas and information.

8. To encourage the superior student to develop his interest and abilities with reference to biology.

CONTENT OF THE INTRODUCTORY BIOLOGY PROGRAMS

The discussion groups achieved generally similar conclusions on what the introductory program should include. In one form or another, all of them listed the following major topics:

1. Structure, living processes and development at the molecular, organelle, cellular, and organismal levels of organization (one group added the societal level).
2. Modern genetics.
3. Evolution, with emphasis on evolutionary processes (one group did not use the term but implied consideration of evolution in various topics in its list).
4. Reproduction (implied but not named by one group).

5. Relationships between organisms and their physical and biotic environments, as related to behavior (only one group used the label "ecology" but all obviously intended to cover basic concepts of interrelationships).
6. Philosophy and history of biology (implied but not listed as a separate topic by one group).

Certain groups attempted to spell out these topics in some detail. For instance the botanical group said:

"While we agree that a fundamental goal in the study of biology is the recognition and appreciation of certain basic principles, we believe that general biology programs should be organized on the basis of the study of plants and animals as functional wholes, objects which can be examined, handled and experimented upon, and that general biological principles should be derived from the study of discrete organisms. The study of individual plants and animals leads to more adequate understanding of the organism as a whole and of the interrelations of its parts and functions.

The study of plants belongs in the college work of every undergraduate for many reasons, among them, the dependence of nearly all organisms upon the process of photosynthesis, the role plants play in the carbon, oxygen, water and nitrogen cycles in nature, the action of plants in stabilizing and conditioning the soil, and the important role plants play in controlling climate.

Plant science topics which belong in the introductory biology program include:

1. Natural history, structure, physiology, and reproduction of flowering plants. Every effort should be made to keep anatomical and physiological details to a practical working minimum.

2. Study of the plant kingdom by means of carefully selected examples, with emphasis upon the importance and methods of classification, and upon the evolution of plant groups. Many life-cycles treated elaborately in many courses could be eliminated; consideration of the algal phyla (except Chlorophyta), mosses, liverworts, hornworts, horsetails and club-mosses, should be reduced and greater emphasis should be given to bacteria, fungi, ferns, and seed plants.

3. Mechanisms of evolution and inheritance in both plants and animals.

4. Ecology and biogeography of both plants and animals and their implications for conservation."

This is what the group meeting as geneticists had to say:

"We recommend that the first-level introductory program include the following material on genetics:

1. Classical Mendelian genetics, including
    a. Multiple factors (quantitative inheritance), and relationship to the expansion of the binomial.

  - b. The relation of chromosomes to genetics, including mitosis, meiosis and chromosome mapping.
  - c. Sex-linkage.
2. Physiological genetics, using microbiological examples to show the relation of chemical entities to gene action.
3. Population genetics to relate genetics to evolution through the Hardy-Weinberg law and its relation to mutation and natural selection. The treatment here used need not go beyond simple cases."

One group, with one strong dissenter, recommended that no attempt should be made to present even a brief phylogenetic survey of the plant and animal kingdoms, believing that the inclusion of other more valuable items will not leave time for an adequate treatment. However, this group did recommend a thorough study of the structure, life processes, behavior, and environmental relations of a few judiciously selected organisms. The other three groups all proposed a brief survey of the plant and animal kingdoms to provide some idea of the range of diversity of organisms.

The introductory program which emerges is one which deals with the more modern and dynamic aspects of biology, with emphasis on such topics as physiology, development, genetics, evolutionary mechanisms, behavior, and interactions with the environment. Although there was general agreement about emphasis on modern concepts, a strong warning was sounded by several of the participants that we should not become so focussed upon analytical and biochemical procedures—upon what might be called the physiological dissection of the organism—that we forget the organism as a whole. This explains the strong insistence in some groups upon behavioral and ecological studies.

The Conferees also urged that the introductory program draws its examples from all the major groups of living things—microorganisms, plants and animals—and clearly show the unique role each group plays in the biological scheme. In this connection the conference considered the role of man in the introductory course or program and reached agreement that the course should not revolve about man. One group stated "Man may serve as a starting point for topics as a motivational device, but the entire course should not revolve about man."

The introductory program visualized by the Conference is conceived to be an essential component in the education of every student. The same course or courses should serve the needs of biology majors and non-majors alike. The course or courses should serve as an adequate preparation for any second level course. The way the course is organized would have to depend on each local situation. In this connection one group had this to say: "How the objectives are achieved and the content represented should be determined by the local situation, provided biologists from all major fields represented at the institution are involved in the planning and execution of the program." Another group said: "We reject the idea of an exclusively zoological or botanical introduction to biology. If the departmental system separates plant and animal biologists in the college or university, mechanisms for cooperation on the introductory program should be found."

Advanced college standing for superior high school preparation in biology was discussed; the consensus favored advanced placement on the basis of superior high school courses, provided standards are adequately safeguarded by examination.

Question II

Beyond the introductory program, what core of biological and other knowledge can be recommended for all future biologists irrespective of their eventual field of specialization?

A. FURTHER COMMON STUDIES IN BIOLOGY

The conferees agreed that, following the completion of the broad introductory program, all prospective biologists should have more intensive training in those areas that underlie the whole of modern biology than is possible in the initial program. Extending through and interconnecting the wide array of biological sciences are a number of basic concepts and phenomena, mastery of which would provide both a comprehensive knowledge of biological principles as they are currently understood and a desirable background for future work in any aspect of biology. The student's future needs are unknown and indeterminable, both because his goals and ambitions may change and because future discoveries cannot be foreseen. We should therefore give him a solid core of information and understanding early in his career and an inquiring attitude toward biological phenomena that can accommodate his expanding, often changing, interests.

An examination of the group reports reveals marked agreement on the content of the common core of training which all prospective biologists should have beyond the introductory course or program. Each group included genetics, growth and development, cell biology, physiology, and ecology or environmental biology. In this connection it should be pointed out that one group considered this additional core training as involving the equivalent of a one-year course during the second year while the other three groups thought of it as involving the equivalent of at least two year-courses. There was general agreement that both plants and animals should be considered in at least part of this common core of study; some groups recommended that both plants and animals should be used throughout. Two groups thought that specialization might begin at some point in this phase of the undergraduate curriculum. One group, while stating that both plants and animals should be used in the work on genetics, ecology, cell physiology and cell morphology, indicated that the additional work in systematics, growth and development, physiology, and morphology might be taken in courses based on either plants or animals. It was felt that no single method of organizing and presenting the materials of the additional common studies could be recommended. In some institutions it may be possible to do this in one or more integrated courses; in other institutions it may be necessary to provide one or more separate courses for each area.

B. REQUIRED WORK IN RELATED FIELDS

The conferees agreed completely that adequate training in biology requires the attainment of a sound knowledge of chemistry, physics, and mathematics.

The following statement was made with reference to mathematics:

1. The composition of the ideal college course in basic mathematics should be different from most present offerings in that there should be less manipulation of figures and more extensive treatment of broad mathematical concepts and their applications.
2. The training should include sufficient experience with manipulation to develop an understanding of basic mathematical concepts, including the rudiments of the calculus.
3. Basic mathematical training should be essentially the same for all college students; that is, no special courses for biology students are envisioned. However, this does not preclude the use of illustrations drawn from the biological sciences in mathematical courses.
4. Additional experience with statistical methods should be available at the advanced undergraduate level.

Three questions were addressed to the group considering training in chemistry.

(1) What chemical background is essential to the study of the biological sciences?

(2) How, under present circumstances, may this be attained?

(3) Would a request for divergence from present programs be desirable and in order?

1. General agreement was expressed that chemistry through organic is essential to the understanding of biology. It was agreed that the biologist requires a body of biochemical and physical chemical concepts for advance in the dynamic aspects of biology, and that at the major level for a bachelor's degree, this represents an essential minimum. Not all of those present favored the inclusion of quantitative analysis in the list of indispensable work in chemistry.

2. It was agreed that the training in chemistry recommended for biologists can generally be obtained in existing courses in two years in many institutions. The consultant, Dr. Arthur Roe, Chairman of the Department of Chemistry at the University of North Carolina, reported that good one-semester courses in organic chemistry exist and that such a course could be initiated by many chemistry departments as a 6-hour course in the sophomore year, with an 8-hour freshman course in general chemistry and qualitative analysis as the only prerequisite. The organic course could be followed in the second term of the sophomore year by a two-hour lecture course on the organic and natural-product chemistry of proteins, carbohydrates and lipids. The consultant noted that courses now given in some institutions are based on this background and cover biochemistry and those aspects of physical chemistry essential to biology.

3. By formal motion, the group recommended that chemistry departments be asked to consider the development of a general chemistry course based upon organic chemistry and qualitative analysis (equilibria, etc.) as a new approach at a rigorous level. Such a course would be of enormous value to biology in permitting effective teaching of dynamic biology early in the program, and would also present a view of chemistry of greater value to the liberal arts student who takes only one course in chemistry than the conventional general chemistry course. The chemists present indicated that such a course is entirely feasible; the main requisites are the preparation of suitable texts and laboratory manuals, arrangements for interchangeability of credits among colleges during the transition to the new type of course, adjustments in courses which follow the first, and changes in entrance requirements of professional and graduate schools. It is also feasible to follow such a general (freshman) course with quantitative analysis, additional organic chemistry, and where desirable, a one-term inorganic course.

It was pointed out that a number of institutions (among them, California Institute of Technology, Brown University, and Pomona College) are currently experimenting with first courses in chemistry involving the organic materials approach. These courses were not designed primarily for biology students, but were initiated by the chemistry departments of these institutions for the improvement of introductory teaching in chemistry. This reinforces the suggestion above, that this kind of course would be useful both to the prospective biologist and to liberal arts students in general.

The physics group unanimously recommended that all biology majors be required to take one year of physics. Reference was made to the fact that physicists must determine the content of the basic course and it was pointed out that a group of physicists considered the problem of content for the introductory physics course at a conference at Carleton College in September, 1956. In the resulting statement, "The American Association of Physics Teachers Report on Improving the Quality and Effectiveness of Introductory Physics Courses," they advocated an emphasis on basic principles and listed the following seven:

1. Conservation of energy and mass
2. Conservation of momentum
3. Conservation of charge
4. Structure of the atom
5. Molecular structure of matter
6. Waves
7. Fields

The conferees subscribed to such a course for all biology students.

Question III

What is the role of the undergraduate program in preparing students for different biological specialties?

The conferees agreed that the college should give the student both a liberal education and an opportunity to get a good grasp on the general field which includes his occupational goal.

The biological sciences have fragmented into a host of specialties defined by organisms studied, approaches used, methods of investigation, applications, areas of employment, and other criteria. Special colleges, schools and departments have grown up around most of these biological disciplines. The Conference did not believe that it could or should propose detailed curricula for all these specialties. This is a task for conferences of those concerned with special fields and for individual institutions. The conference did believe, however, that they could delineate some guiding principles that might help those interested in the major areas of specialization in designing programs. To do so, the members first separated into groups based upon areas of professional employment: (1) botany; (2) zoology; (3) agricultural and conservation biology; (4) medical biology; (5) precollege teaching. After considering these areas, conferees then divided on the basis of areas of biological inquiry: (1) molecular and cellular biology; (2) regulatory biology; (3) developmental biology; (4) genetic biology; (5) systematic and evolutionary biology; (6) group and environmental biology.

The conferees emphasized that the small college should attempt to offer only the core program plus a small selection of these specialties. The biology staff of the college could thereby dedicate their time, energy and facilities to the development of a strong basic program. They would not fall into the situation of the two-man department which offers twenty-five different courses. The large university with many biologists and numerous departments, on the other hand, can offer specialized work in many or all these areas.

BOTANY

The botany group recommended no specific courses which the student specializing in botany must take. However, they recommended that the courses offered by any institution should enable the student to obtain, during his undergraduate program, a comprehensive knowledge of the plant kingdom and of the structure and function of plants. This recommendation was based on the assumption that the introductory and core programs would adequately cover the subject matter from the plant sciences, already referred to.

ZOOLOGY

In addition to the introductory and core programs, a major program in zoology should include substantial additional work on both the morphology and the physiology of animals. While the content and structure of particular courses must be left to the discretion of individual departments and instructors, it was suggested that this additional work in zoology could be accomplished by two one-semester courses at the junior or senior level, one primarily on physiology and the other chiefly anatomical. Both should, of course, include laboratory work, and both should involve comparative study of invertebrate as well as vertebrate animals. A minority of the group suggested that it would be better to organize these two courses on an organ-system basis, essentially a year-course involving an integrated study of comparative physiology and morphology of animals.

Ecological relationships and the behavior of the whole animal should be kept in mind throughout such courses and emphasized wherever appropriate, but these topics should not be required as separate courses. Similarly, the historical and philosophical aspects of biology should be considered, not in separate required courses, but as part of the subject matter of upper level courses and of those constituting the common core program.

While the principles of growth and development form part of the recommended common studies for all biologists, some of the group felt that for the zoologist these studies should emphasize animal embryology. As an alternative, embryology might take a prominent place in the upper level course on animal morphology.

There should be further optional courses in special areas of zoology, and it is especially important that the more able and enterprising students be encouraged to undertake independent reading and/or research in the field or laboratory. Optional specialized courses should be available as electives only to the degree permitted by the staff and resources of the institution, without weakening the common studies recommended for all biologists and the basic upper-level work for zoology majors on the morphology and physiology of animals.

AGRICULTURAL AND CONSERVATION BIOLOGY

This group urged greater recognition by agricultural and conservation biologists of the values to be gained through studies in the basic sciences of the way agricultural information is developed, in place of devoting excessive student time to such matters as crop varieties and animal breeds. The speed with which this latter kind of information becomes outmoded indicates the wisdom of providing educational experiences more likely to be of enduring worth. Within the major area the best preparation emphasizes basic scientific disciplines and minimizes specialized, detailed courses.

A single orientation course for all agricultural fields, covering forestry as well as all agricultural specializations, was considered preferable to introductory courses in each curriculum (*i.e.*, replace Agronomy I, Horticulture I, Animal Husbandry I, Dairy Science I, Forestry I, etc., with Agricultural Sciences I).

They endorsed, as highly desirable for students in agricultural and conservation biology, the proposal that departments of chemistry be encouraged to develop rigorous first-year sequences in general chemistry based on organic compounds to replace the year of inorganic chemistry traditionally offered.

In line with recommendations on Questions I and II, this group felt that the most desirable arrangement for undergraduate students in agricultural and conservation biology would allocate no more than one-half of their program to biological and supporting science courses.

Not more than one-fifth of the training in the biological and supporting sciences (10%) of the total undergraduate program) should be devoted to studies in the student's specialized agricultural or conservation field.

MEDICAL BIOLOGY

Students who plan to make a career of medicine or medical sciences should include in their program the material suggested for all biologists under Questions I and II. Their program might also include additional experience in depth in areas of *dynamic* biology.

Even more important, the future medical scientists or physician should have experience in the design and execution of experiments. At present many medical school curricula provide little opportunity for this kind of experience. This type of activity should therefore be encouraged during the undergraduate years.

The group recognized that there is unnecessarily wide divergence among American medical schools in their admission requirements. Moreover, there is little relationship between the printed philosophy, as it appears in medical school catalogs, and the actual demands of medical faculties. This results in confusion in counseling students. The rigidity of the printed requirements has also tended to have a constraining effect on undergraduate biology teaching.

In recent years there has been a notable effort, through conferences and special studies, to emphasize the importance of a broad liberal education as preparation for the study of medicine. This was considered to be sound philosophy and a healthy reaction against the excessively narrow requirements of past decades. The pendulum may have swung too far, however. They believe that the curriculum recommended by this conference, for example, would meet both the desire to give premedical students a liberal education and their need for substantial basic work in the biological sciences, chemistry, physics and mathematics.

They recommended that a conference be called to bring college and medical educators together for an exchange of views that might lead to a more nearly uniform philosophy of premedical education. This, they believe, would benefit both biology and medical education.

TEACHERS FOR SECONDARY SCHOOLS

The group dealing with special work for biology majors planning to become teachers of high school biology recommended only two additional elements of preparation beyond the core program specified in Questions I and II:

1) Further study of field biology. The "natural history" approach (identification, ecology) has frequently proven effective in stimulating interest in biology at the high school level, and the teacher is usually regarded as the local expert in such matters.
2) Further study in methods, such as the devising of interesting laboratory experiments. This course should be taught in a biological department as a thoroughly respectable scientific course but it should yield credit in the Education department, applicable to the education requirements for graduation and certification.

With the addition of these two items, the group believes that the competence in subject matter established in the core program for biologists is a thoroughly satisfactory preparation for high school teachers of biology, and should constitute the minimum requirement for their certification. They strongly recommended that the secondary-school teacher should major in the field in which he plans to teach. The biology teacher is also likely to be called upon to teach general science and often other science courses. The work in mathematics, chemistry and physics included in the core program will help prepare him for this; some study of earth science would also be a valuable adjunct to his training.

They further recommended that not less than one-half of the undergraduate training of the prospective biology teacher be in biological sciences and supporting physical sciences and mathematics.

With regard to experience in supervised teaching, they recommended that every potential biology teacher obtain experience as a supervised college laboratory teaching assistant, and that this be counted as an essential part of his practice teaching.

They believe it to be very important that biological departments do their utmost to give status to high school biology teaching, and that to this end they seek to establish and maintain close ties with their own graduates and with other teachers in their locality. Teachers should be encouraged to come to these departments for assistance on laboratory and teaching problems and for help and information on their continuing biological education.

They believe it highly desirable that the major part of in-service training for biology teachers be in biology and the supporting sciences, rather than in additional courses in Education, and they recommend the further development of the summer institutes sponsored by the National Science Foundation and similar programs. They think it very important that the teacher be encouraged and assisted in every way to keep up with advances in his field and to associate professionally with other biologists.

The reports of the groups meeting according to areas of inquiry are both interesting and instructive. However, this paper is already too long and I will simply ask you to read these when the full report is circulated.

In closing may I emphasize a statement made in the Conference report. "A report or a conference such as this one is no more than an effort by one group of biologists to outline some guidelines on curriculum planning for consideration by their colleagues. Only the individual professor, the individual department, the individual institution can determine what program will actually be offered to individual students." It was the hope of the conferees that the report on this conference would encourage more biologists to make their own critical assessments of undergraduate curricula.

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3. Johnson, W. H. (chairman). 1958. *Recommendations of the Conference on Undergraduate Curricula in the Biological Sciences.* Sponsored by the Committee on Educational Policies, Division of Biology and Agriculture. National Academy of Sciences—National Research Council, Washington, D. C. (*in press*).

ANTHROPOLOGY

Chairman: William R. Adams, Bloomington, Indiana

Emily Blasingham, Indiana University, was elected chairman for 1958

ABSTRACTS

Wife Stealing in Central Mexico. Harold E. Driver, Indiana University.—Census data on the Chichimeca-Jonaz Indians reveals that over half the wives in the past three quarters of a century have been "stolen" by their husbands before either the civil or church wedding ceremony had been performed. Although there are a few cases where the bride was actually kidnapped against her will and perhaps even raped before she had become receptive to her abductor, we believe that most such cases are better classified as elopement. Although this custom may be an old Indian practice, it has been increasing in frequency in the 20th century both among the Chichimeca-Jonaz of the state of Guanajuato and their Tarascan neighbors about 100 miles south in the state of Michoacan. The causes of this increase are not entirely clear, but it may be related to the diminishing authority of the Catholic Church during this period.

Southern Affinities of the Ellerbusch Site, Warrick County, Indiana. Frances Patton Martin, Newburgh.—Complicated stamped pottery with Georgia Swift Creek curvilinear and concentric circle designs was found on the Ellerbusch Site, W^{v}56, during an archaeological excavation started in May 1957. Associated with the 41 sherds of this clay tempered sandy paste ware were 61 cord marked and 18 plain sherds with varying amounts of sand and clay tempering, six rim sherds with impressed lips and three with plain lips, a hammer stone, a bi-pitted rectanguloid stone, 3 partial projectile points, two plano-convex flint cores, 16 prismatic flake knives and fragments of mica and cannel coal. All evidence available indicates that this deposit accumulated during the Middle Woodland occupation of the site which also has Middle Mississippi and Archaic remains. Pottery diagnostic of Marksville-Hopewell has not been found there so far although it is plentiful on the three other Indiana sites where Swift Creek type pottery is abundant. Two of these sites, Po^{v}2 and Po^{v}14, are in Posey County and the other, Vg 44, is in Vanderburgh County. One sherd with a Swift Creek concentric circle design has been found in Spencer County on Sp 38, making a total of five known sites in Indiana with Swift Creek affinities.

The Ottawa in the Early Historic Period. Emily J. Blasingham, Indiana University.—An investigation of factors contributing to a change in Ottawa economy from mere subsistence agriculture to raising surpluses of food for trade purposes. The Ottawa during the period under consideration in this paper lived at the extreme northern limits of maize cultivation; however they became extensive agriculturists and the surplus of food (especially maize) which they grew in large measure enabled the French to exploit the western Great Lakes region. It is the purpose of this paper to point out and describe the various factors which assisted the Ottawa in this economic change.

Pottery Ornaments from Rio Tapajós, Brazil

Francis X. Grollig, Indiana University[1]

"Aborigine pottery ornaments from a village site on plateau near Bellaterra, Rio Tapajos, Brazil. Coll[ected by] J. R. Weir, 1934-38." This little note on the top of a stationary box doesn't say much, but it tells us all that we know of the origin of these pieces of Amazonian art collected by the late James R. Weir of Edinburg, Indiana.

The Rio Tapajós flows North into the Amazon River and on the South East bank at this junction is the village of Santarém. Rain was the first "archeologist" to do extensive excavating at Santarém: "a cloudburst washed out the streets of Santarém and uncovered stone tools and a great quantity of pottery" (1). This was in the summer of 1922, and it was the beginning of the formal definition of the Santarém complex. The items here described belong to that complex, which, says Betty J. Meggers, "is perhaps the most remarkable in the Amazon Valley". The paste is light grey in cross section and light tan on the surface. Santarém pottery is notable for its unusual shapes and profusion of modeled bird and animal ornament" (1). Descriptive notes on a few such ornaments follow.

Designs are: a) geometric, No. 10; b) anthropomorphic, Nos. 6, 7, 8, & 11; or zoömorphic, 1, 2, 3, 4, 5, & 9. The numbers refer to the ornament numbers in plate 1.

An ichthyologist could identify the fish heads represented in Nos. 4 & 5; but to the uninitiated the former is a naturalistic and the latter is a stylized representation of the finny family. The hole which pierces below the eye of No. 4 is the place for a cord or thong with which to carry the vessel to which this ornamental handle was attached. In No. 5, the eyes are appliqué and the facial lines are incised. The tiny trout-like mouth is cut into the bottom corner of the face.

Of the other zoömorphs, Nos. 2 and 3 represent caymans, but the eyes differ: dots of clay are applied in No. 2, while in No. 3 they are projecting fillets with a neat circle depressed around the eye-balls. The conventionalized punctate decoration motif is repeated.

The color of No. 2 differs from all of the other pieces—which are the usual grey paste and light tan fired area. No. 2 is pink on the bottom of the rim and on the interior of the vessel. This may be the result of intensive firing. The only piece here that manifests a certain aboriginal paint job is the frog, No. 1, which has a bit of red paint on the interior of the vessel. We note that the artist caught the dynamic nature of this little amphibian by placing his hind legs in a jumping position.

There are traces of black stain on the surface of No. 9, a beetle—a common motif in Amazonian pottery ornaments from the Santarém

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[1] Photograph and original drawings by Robert E. Easton.

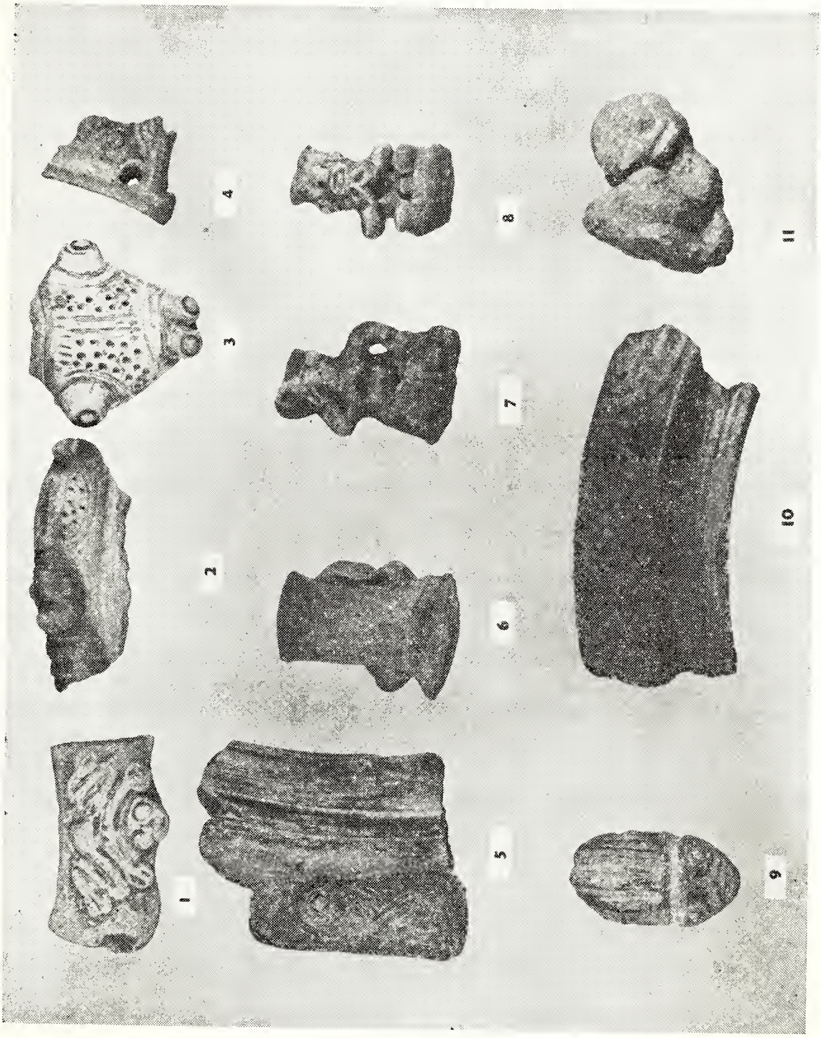

Plate 1. Pottery Ornaments from Rio Tapajós, Brazil.

area (2). This may be aboriginal, but the light blue paint (which also appears on rather freshly broken surfaces of other pieces in this collection), is almost certainly a non-aboriginal modification.

The rim of No. 10 exhibits a very neatly expressed fillet in a geometric pattern. But the really interesting facet of this piece is the cross-section, for it is hollow. A diagram of this is given in plate 2.

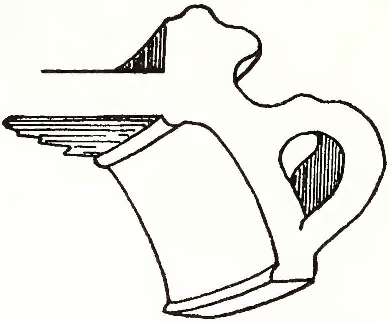

Plate 2. Hollow Rim of Dish, Cross Section.

The slight slit at the top of the hollow interior indicates that the rim was drawn out of the side section of the dish and carefully remolded into the vessel at the top of the rim; it is not a separate piece of clay added to the dish.

Of the anthropomorphic items, No. 11 represents a child clinging (possibly) to its mother. The inside of this ornament is hollow, but not light tan. Therefore, the inside does not represent a fired surface. So, this is (probably) a curious double ornament: the child (made of at least three pieces of clay) is attached to the breast, and this, in turn, is attached to the vessel. The alternate, of course, is that this is simply a part of a large hollow figurine, and not a complete ornament by itself.

The group, Nos. 6 (rear view), 7, & 8, is composed of caryatids. Plate 3 illustrates their function in Santarém pottery. No. 6 shows

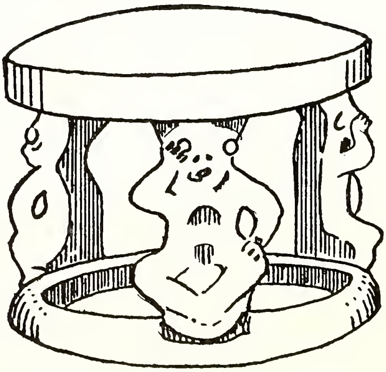

Plate 3. Caryatids.

how the caryatid is fastened to the annular base and to the bowl of the supported object, which can be a dish, plate, or cup. The positions of Nos. 7 & 8 approximate the monkies of "See-no-evil" and (?) "Speak-no-evil" fame. These three are solid figurines in the round, but obviously not from the same "vase a pied".

Even so cursory a glimpse at Santarém pottery, as this perforce must be, is enough to lead one to begin to see why Nordenskiöld could write (15 years before Betty Meggers said the same thing): "De tous les lieux d'Amazonie d'oú a été exhumée de la céramique, c'est peut-être Santarem le plus remarquable" (2).

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The Findings After Two Years of Work at Serpent Mounds Site, Rice Lake, Ontario

RICHARD B. JOHNSTON, Indiana University

During the field seasons of 1956 and 1957 the Royal Ontario Museum has conducted full-scale archaeological investigations of the Serpent Mounds Site, on Roach's Point on the north shore of Rice Lake, in Peterborough County, Ontario. Although excavations were made at this site as early as 1895, the work of the last two years has been the first systematic and exhaustive examination of the mound group and related features.

The principal mound, from which the group takes its name, is an earth structure slightly less than 200 feet in length. The mound varies up to seven feet in height, the mean width being approximately thirty-five feet. Three distinct angles along the long axis lend a zig-zag appearance and account for designation of the mound as a "serpent". Just beyond the eastern, or head, end of the serpent is the second largest mound in the group, a flat-topped oval structure with approximate maximum dimensions at the base of thirty-seven by fifty feet. Six other smaller conical or oval mounds are included in the group. Four of these are located just south of the two main structures, one of which is apparently two conjoined mounds. Nearby, on the slope below the mounds closer to the shore line of Rice Lake, are extensive deposits of mussel shell containing habitation refuse. It may be logically expected and there are indications that a village area exists somewhere in the immediate vicinity but the present investigation has thus far been confined largely to the mounds.

The first documented excavations at this site took place in 1895 under the direction of Dr. David Boyle (1). He dug trenches in several of the mounds, recovering skeletal material and artifacts. Boyle, incidentally, at this early date, encountered considerable evidence of previous digging. Fourteen years later, in 1909, further test pitting was carried out in the Serpent Mound by Henry Montgomery (2). Written reports appeared after each of these excavations but they provide only a tantalizing glimpse of the work and results. It is difficult even, on the basis of these accounts, to precisely locate the old excavations.

In 1955 the current program of work was undertaken by the Royal Ontario Museum as part of the development, in cooperation with the Ontario Department of Lands and Forests, of a 70-acre Provincial Park centered around the mound group. A survey party spent three weeks that year at the site and completed preliminary excavations. During the past two summers work has continued with the excavation of ninety-three 5-foot squares in and around the eastern portion of the Serpent Mound.

Generally speaking, the effort has been mostly productive of burials. To date twenty-nine have been recovered, twelve of which came from various levels throughout the Serpent Mound itself. Nine of these were primary interments in a flexed position. Two individuals, a male of 27 and a female 13 years of age, were found in a shallow grave in the old surface under the mound. They were buried in a flexed position, back to back and head to foot. A wolf mandible was included in the grave and three copper beads, indirectly associated, were recovered from the surrounding fill. An inch and a half long side notched isoceles flint point was found with another burial that was flexed and placed lying on its back with the face up and the knees drawn over the pelvic area. Another primary burial showed overall cremation while a second, found within a foot and a half of the surface in mound fill, was burnt about the head and neck. Two interments may be characterized as bundle burials while another secondary burial appears, except for the legs, to have undergone partial dismemberment. Various artifacts and refuse as pottery fragments, silver, copper and shell beads, beaver teeth, projectile points, animal bone and mussel shell have been recovered but only in mound fill where they cannot be associated directly with the burials.

Partial excavation of one of the small oval mounds adjoining the Serpent Mound revealed a mass grave containing primary and secondary burials of at least seventeen individuals. Again, grave goods were not found although some material was recovered from the shadow fill. Most of the burials appear to have been placed in a pile, ossuary fashion, along the long axis of the mound. Here again the practice of dismemberment is evident. Two primary burials, of three in the bottom of the grave, were placed face down with the legs fully flexed.

Four test squares have been completed in the shell deposits on the slope below the mound group. This exploratory excavation has shown the area to hold much promise as already considerable pottery and other refuse has been found in stratified deposits. As yet the exact cultural connection of the shell accumulation to the mound group has not been determined, although certain similarities have been noted.

The unique character of the Serpent Mounds Site is a major factor contributing to its importance to regional archaeology. To the author's knowledge it is the only serpent effigy in Canada and one of very few in North America. The cultural position of the component has not been fixed among a number of possibilities, including speculative reference to Adena-Hopewell cultures to the south in the Ohio Valley. Such connection would be of special interest in view of the site's geographic and cultural isolation from the Ohio Valley and the groups therein. Thus far we seem to be dealing primarily with and know most about the burial complex. Grave goods, other than previously noted, have been lacking and this paucity has tended to obscure cultural affinities. Ceramic analysis, when completed, will afford important additional evidence. More work in the field and with the material recovered will be necessary before an adequate appraisal of relationships can be made.

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BACTERIOLOGY

Chairman: Edward W. Shrigley, Indiana University

Walter Konetzka, Indiana University, was elected chairman for 1958

ABSTRACTS

The Effect of Formaldehyde on the Agglutination of Red Cells by Antiserum Against Artificially Attached Antigens. J. S. Ingraham, Indiana University Medical Center.—It has been observed that treatment with formaldehyde renders human red blood cells nonagglutinable by specific blood group antisera (Cole, L. R. and Farrell, V. R. J. Exp. Med. **102**:631, 1955). Moskowitz and Carb (Fed. Proc. **16**:426, 1957) reported that cells made nonagglutinable by formaldehyde still adsorbed blood group antibodies as specifically and avidly as fresh cells and concluded that the effect of formaldehyde is not directly on the blood group antigens.

Red blood cells coupled with sulfanilazo groups are agglutinated specifically by antiserum against the attached groups. In the work reported here it was observed that treatment of these cells with formaldehyde either before or after attaching the hapten groups abolished agglutination by antiserum when observed by the customary slide test or by a tube test using centrifugation and resuspension. This is in agreement with the work cited above and strongly supports the conclusion of Moskowitz and Carb. However, as judged by a rate-of-settling technique or by settling pattern the formaldehyde treatment had little effect on the agglutination. These observations emphasize the importance of accounting for nonspecific factors in any theoretical treatment of immune agglutination.

Formalin treated cells bearing attached hapten groups are a convenient and very sensitive antigen for the detection and measurement of antibodies homologous to the attached groups. We are presently using these antigens to investigate the formation in rabbits of antibodies homologous to simple chemically defined hapten groups.

Sensitivity of *Streptomyces* Species to Ultra-violet Radiation. Thomas C. Nelson and Robert E. Nichols, Eli Lilly and Company, Indianapolis.—Ungerminated spores of various *Streptomyces* species: *griseus*, *hygroscopicus*, *erythreus*, and *orientalis*, gave different survival curves when irradiated with short-wave ultra-violet from germicidal lamps. Spore suspensions suspended in nutrient broth were irradiated in shallow layers at an intensity of 40 microwatts per square centimeter. Surviving spores were determined as colonies formed after incubation on various nutrient media.

The kinetics of the *S. hygroscopicus*, *S. erythreus*, and *S. orientalis* curves are of the one-hit type. The kinetics of the *S. griseus* curves are multi-hit, with the number of hits varying between 2 and 60.

The inactivation energy required to reduce the survival of spores to 37% of the initial number, corresponding to an average of one effective hit per spore, is 32×10^3 ergs/cm^2 for *S. hygroscopicus*, 76×10^3 ergs/cm^2 for *S. orientalis*, and 48×10^3 ergs/cm^2 for *S. erythreus*. The inactivation energy for *S. griseus* varies inversely with the multiplicity of the curve, from 12×10^3 ergs/cm^2 at 50 to 60 hits to 29×10^2 ergs/cm^2 at 2 hits. Spores germinated in agitated medium gave a one-hit curve with a sensitivity slightly less than that of the 2 hit ungerminated spores.

A fraction of the spores is resistant to killing by ultra-violet, the fraction varying considerably between experiments. The resistance is physiological rather than genetic and may be due to clumping of spores and mycelial fragments.

Treatment following irradiation affects the survival. Exposure to visible light, or pre-incubation at low temperature, results in reactivation.

A correlation of radiation kinetics with the amount of sensitive material, presumably desoxyribose nucleic acid, and its distribution by chemical and cytological analysis, may be used to determine the growth cycle.

Bacteriological Problems in Food. GLEN C. WEBER, Indiana State Board of Health, Indianapolis.—Recent developments in Food Technology coupled with a changed sociological pattern have brought about a revolution in food preparation and distribution methods, and in eating habits. More meals are being taken away from home and more pre-packaged foods, particularly the frozen and refrigerated types, are being consumed. This implies a potential threat to Public Health, inasmuch as many of these items have been handled after heat treatment, and have not received final post-packaging sterilization.

Survey work has shown that some foods have high counts of bacteria; some are contaminated with fecal organisms; and some are carrying definite pathogens. The problem is complex because of the diversity of formulae, processing technics, and dispensing methods employed by different processers and retailers.

There is shown to be a need for an intense study of the situation, in order to determine the extent and degree of the danger, and to find ways for keeping it under control.

An Improved Combination of Optical Instruments Useful in the Bacteriological and Biological Laboratory. P. S. PRICKETT, E. F. HARRISON, H. R. WILLIAMS, JR. and H. L. MURRAY, Research Laboratories Mead-Johnson and Company, Evansville.—The combination consists of a monocular compound microscope and a Euscope.[1] The latter projects the microscopic image onto an opaque vertical screen for viewing by one person, or by turning a lever to move the opaque screen out of the optical path, onto a vertical ground glass screen for viewing by several persons.

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[1] Euscope is the name trademarked by Bausch and Lomb for this instrument.

The improvements consist of equipping the microscope with a variable focus substage condenser and a hyperplane ocular, plus an adequate light source. The first enables the operator to obtain critical illumination rapidly and easily with a fully and uniformly illuminated field at any magnification, particularly important with projected images. The second gives a clearer, flatter projected image, thus almost entirely correcting the usual highly curved image ordinarily obtained with a short projection distance and the commonly used huygenian ocular.

In the teaching laboratory, probably the ground glass viewing screen, by means of which the microscopic image can be seen by a group of students, would be more useful. Since the image is magnified about two times when thus projected, frequently the specimen can be satisfactorily demonstrated under high dry magnification without having to resort to the oil immersion objective. The specimen can also be demonstrated rapidly and satisfactorily at lower and higher magnifications.

In the industrial laboratory, the opaque screen viewed by a single person, has proven the most practical. It is quite useful for the rapid microscopic examination, without fatigue or eyestrain, of large numbers of preparations, particularly under low and high dry magnifications. The image thus seen is magnified 1.5 times by the viewing glass of the Euscope.

BOTANY

Chairman: Alton A. Lindsey, Purdue University

Fay Daily, Butler University, was elected chairman for 1958

ABSTRACTS

Field Efficiencies of Sampling Methods in Forest Survey. Alton A. Lindsey and S. R. Miles, Purdue University.—A statistical comparison of field efficiency for the new Bitterlich method, compared with square and circular quadrats of different sizes, was made. Intensive sampling in the laboratory was done from a 1:36 scale map of 20 acres of practically undisturbed Donaldson's Woods, Spring Mill State Park, Lawrence County, Indiana. The resulting data were used to determine for each method the number of trees required for sampling for density and basal area with 15 per cent standard error. The time for each sampling method, in seconds per tree, was determined in the actual woods. The product of these factors, expressed in hours, is field efficiency. The most efficient method tested is a proposed combination method fully operable from the point where the observer stands. It combines the basal area part of the Bitterlich method with the density part of the circular tenth-acre plot made by six-inch-base rangefinder from the central point. The operator turns through 360° once with an angle-gage and again with the rangefinder. No measurement or estimate of tree diameter is required, and no plot boundaries are laid out. By the new combination method, 1.7 hours are required to obtain an adequacy level of 15 per cent standard error for sugar maple, the species ranking third in density and fourth in basal area in this stand. The complete Bitterlich method, as used for both density and basal area, required 3 hours. Circular plots by rangefinder, and measuring trunks by diameter tape, were more efficient than square plots surveyed by diagonals N-S and E-W from the central point, and marked by flags at the corners. Tenth-acre circle plots required 2.5 hours; one-fortieth-acre plots took 5.9 hours. Fifth-acre squares required 4.8 hours, tenth-acre squares 5.4 hours, and fortieth-acre squares 8.9 hours.

Some Ecological Correlations in Indiana. Thomas G. Overmire, Shortridge High School, Indianapolis.—An attempt has been made to account for the distribution of certain trees, ferns, mammals, birds, etc., by the correlation of such factors as: elevation, types of soil, soil acidity, land forms, glaciation, and seasonal climatic variations.

Mechanisms of Pollination and Seed Dispersal in *Lithops*. J. A. Jump, University of Notre Dame.—The species of the South African endemic, *Lithops*, are reported to be self sterile. The numerous stamens form a central free-standing androecium with a convex upper surface, resulting from the anthers being held closely together. Experiments with artificial and natural rain show that a drop of water falling upon the center of the open, upright flower will scatter the pollen in the spattering droplets and effect pollination of nearby plants. This does not preclude the possibility of insects as the major agents of pollination under natural conditions.

Seed dispersal can apparently take place readily only by means of raindrops. The seed are contained in deep loculi of the capsules which are held stiffly upright between the single pair of leaves. Several drops of water are required to open the hygroscopic capsule initially, and subsequent drops falling upon the open loculi effectively scatter the seed to a maximum distance of at least 1.3 meters. Imbibition pressures in the neighborhood of 1000 atmospheres may be developed by the cells responsible for the opening of the capsular valves. The valves close upon drying and the process may be repeated.

Conjugation in *Netrium*. PAUL BIEBEL, Indiana University.—Recent studies have shown that the sexual cycles of desmids can be obtained in culture and that desmids can yield fruitful results in the study of genetics and morphogenesis. Research has for the most part been confined to the placoderm desmids (Desmidiaceae) while the closely related family of saccoderm desmids (Mesotaeniaceae) has been neglected. Successful isolation of several saccoderm desmids has made a study of their life cycles possible.

A strain of *Netrium digitus* (Ehr.) Itz. and Rothe was isolated from a pond in Brown County, Indiana. Conjugation was obtained in pure culture on chemically defined media. The strain proved to be homothallic. Conjugation was obtained when cells were plated on Bristol's agar or on agar containing no nutrients. Conjugating cells were always darker green than cells from a vigorously growing vegetative culture and had such an abundance of reserve food material that the chloroplasts were obscured. The cells produced lateral processes which fused to form a broad conjugation tube. A spheroid zygospore having four chloroplasts oriented in quadrants was formed within the tube. During ripening the zygospore secreted three walls, the outermost of which was smooth and hyaline, and the chloroplasts became yellowish-brown. Germination of zygospores has not been obtained.

A Tripsacum-Corn Hybrid. L. I. FARQUHARSON, Franklin College.—A mature plant has been obtained from the crossing of *Tripsacum dactyloides* with *Zea mays*. The maternal parent is a tripsacum plant from southern Indiana and possesses a somatic chromosome number of 54. The corn used as the pollen parent came from Puno, Peru. Since 64 chromosomes exist in the somatic cells of the hybrid, it is assumed that the egg cell carried the unreduced number of chromosomes. The hybrid plant resembles the maternal parent very closely. The increased length of style, width of leaf and the meiotic configurations, however, clearly indicate that this plant is not an apomict. It is suggested that this cross may occur occasionally in nature and may have been responsible for some transfer of genetic material between the two genera in comparatively recent times.

Buried Forests of Indiana. H. O. BEALS, Purdue University.—During the Pleistocene (Ice Age), parts of Indiana were covered by glacial ice at least three times. Forests and trees growing in the path of the advancing glaciers were buried by glacial debris. In recent years, a number of these forest beds have been exposed through erosion, road cuts, and other means and have been described by glacial geologists. Identification by wood anatomy indicates that these ancient forests were mostly conifers of a Spruce-Larch type.

Relation of the Formation of Annual Rings to Multiple Flushes of Growth in Several Species of *Quercus*

A. T. Guard and S. N. Postlethwait, Purdue University

It has been stated rather widely in the literature that if woody species of the temperate zones undergo two separate and definite periods or flushes of growth, so-called false annual rings will occur in the xylem. Doubtless this does occur under certain circumstances but preliminary observations lead the authors to question the universality of this statement.

A most suitable material for investigation of this problem seemed to be woody species that possessed both a definite terminal bud, when dormant, and ring-porous type of xylem. Since *Quercus* possessed both of these characteristics it seemed advantageous to utilize species of this genus.

Materials and Methods

Specimens of *Quercus palustris*, *Q. bicolor* and *Q. macrocarpa* were investigated. The trees used in this study were vigorous young trees with a d.b.h. of from 12"-18". They were growing out in the open under favorable conditions. Both the initial growth and the second flush bore well developed mature leaves. A mature scaly terminal bud was present on the second flush and the number and size of the bud scale-scars on the first flush indicated that a fully developed terminal bud had been present prior to the beginning of the second flush of growth. Growth in length of the branches studied was from 15-19 cm. per period of growth.

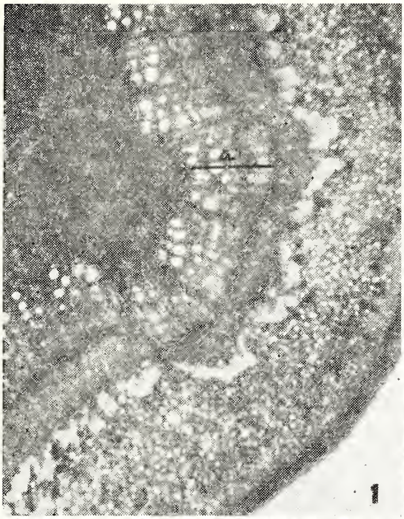
These branches were cut and brought into the laboratory where free hand sections were made and mounted for study.

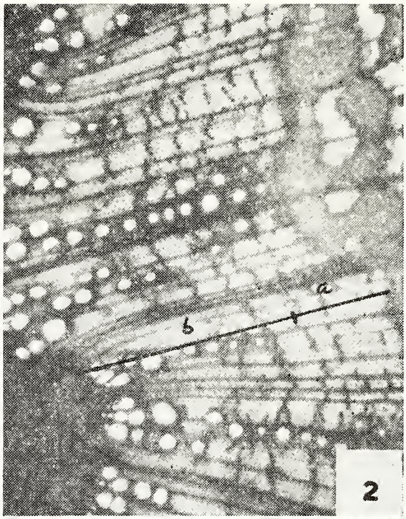
Sections were stained in phloroglucyn and dilute hydrochloric acid in order to make evident the degree of lignification which had occurred. These sections were then dehydrated in ethyl alcohol, cleared in xylene, and mounted in balsam. With this procedure the sections remained in a satisfactory stained condition several days, which enabled one to study and photograph them.

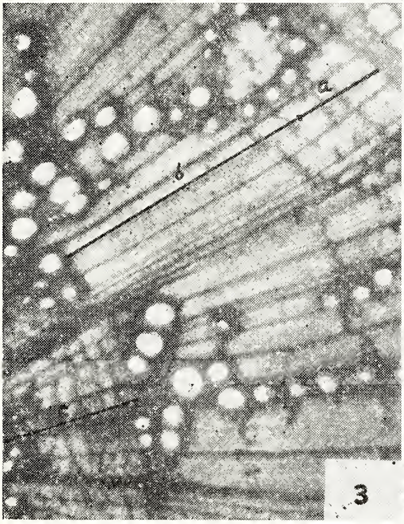
Observations

In general the development of the three species followed a very similar pattern, consequently, most of the description will be based upon *Q. palustris*.

In the most recent flush the vessels and fibers were moderately well lignified except in the immediate region of the cambium (fig. 1). Where a full winter season existed between flushes a ring porous condition, characteristic of these species existed (fig. 4). However, as is shown in (fig. 2), which is a section through both the first and second flush of 1957, there is no definite evidence of a false ring. Indeed, it is very







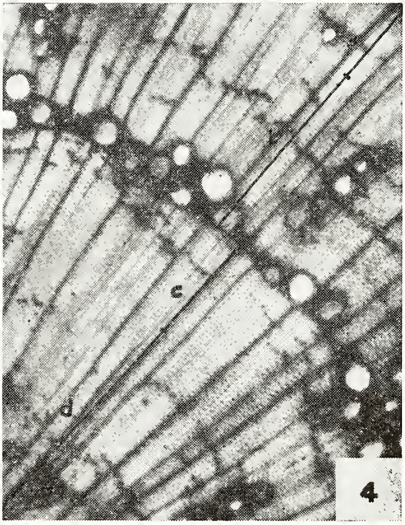


Fig. 1. Section of stem showing the second flush of growth for 1957.

Fig. 2. Section of stem showing first and second flush of growth for 1957. Note absence of false ring.

Fig. 3. Section of stem showing first and second flush of 1957 and second flush of 1956.

Fig. 4. Section of stem showing most of the xylem produced in each of the two flushes of 1956 and 1957 respectively. a. second flush 1957, b. first flush 1957, c. second flush 1956, d. first flush 1956.

difficult to tell any line of demarcation between the xylem of the first flush and that of the second.

A similar situation occurred during the previous year 1956, as determined by the bud scale scars. Thus in this branch represented by figure 4 there were two distinct periods of growth in 1956 and two in 1957. There is one clear ring of vessels between the growth of 1956 and 1957. However, between the two increments which occurred in each of the years respectively there is no evidence of a so-called "false annual" ring. Another feature of growth under this situation is the more irregular distribution of large vessels (fig. 3).

Discussion

The oaks which are definitely ring porous and with a well developed terminal bud during the dormant season seems to be excellent material to study the development of false annual rings. Eames and MacDaniels (1) say, "In trees with determinate growth, such as the oak, the winter buds, especially the terminal buds, may begin growth prematurely in late summer; the consequent growth activity is accompanied by the formation of a false ring".

Obviously this has not been the case in branches used in this study. There is, however, one difference in the situation of this study and the statement of Eames and MacDaniels. They say in late summer. This second period of growth occurred in mid-summer. Although the two flushes of growth were very definitely separate and distinct, as evidenced by formation of scaly terminal buds, they were apparently separated less than one month in time.

Söding (2) has suggested that cambial activity is initiated under the influence of auxins produced by the opening buds. Wareing (3) has proposed further that the rapidity of the spread of cambial activity in ring-porous wood as compared with diffuse porous wood may be due to the presence in the cambial region of a high initial reserve of an auxin precursor.

If the proposition of Wareing is correct the absence of false rings in the present study may have been due to the relative short duration of time between the cessation of growth in the first flush and the initiation of activity by the next flush.

Evidence at hand does not allow a definite conclusion on this hypothesis. There is obvious evidence, however, that in the species studied, even though they are ring-porous and develop a definite terminal bud, renewed periods of terminal and cambial growth do not always result in false annual rings.

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2. SÖDING, H. 1940. Weitere Untersuchungen über die Wuchstoffregulation der Kambiumtätigkeit. Zeitschrift f. Bot. 36 :113.
3. WAREING, P. E. 1951. Growth studies in woody species. IV. The initiation of cambial activity in ring-porous species. Physiology Plantarum 4 :546-562.

A Basidiomycete Which Sporulates in Artificial Culture

Robert P. Daniels and C. L. Porter, Purdue University

In the spring of 1957, we received a fungus culture from Mr. Paul Everett, a graduate student in Agronomy. He requested that we attempt an identification of it.

As we received it, it was growing on wheat stems in a Petri plate. No fruiting structures were present at the time; only a dense, white, felt-like growth. The plate was set in a 25° C incubator and forgotten. Several days later when the plate was examined we found that fruiting had occurred. The sporocarp was so appressed against the plate top that it was distorted. Transfers were made to potato dextrose agar (Baltimore Biological Laboratory) slants using the sporocarp as well as the vegetative growth for inoculum. Microscopic examination showed an abundance of clamp connections in the vegetative mycelium. Later transfers were made from the tube slants to large Fernbach flasks containing nearly one liter of potato dextrose agar. These showed only a few sporocarps after several weeks. Vermiculite was suggested as a base instead of agar. Using an entirely organic medium, except for the addition of phosphate, with vermiculite, we obtained a culture which sporulated continuously in great abundance for several weeks. As many as six to eight sporocarps matured in a single stand and as many buttons were already in evidence at this time. The characteristics of the sporocarp have led us to place this fungus in the genus *Paneolus*.[1]

We were desirous of obtaining more exact information concerning the source of this fungus and the conditions under which it was isolated. An interview with Mr. Everett did not yield any specific source except by inference. His work involves studies of the decomposition of organic materials in soils of varied composition. The fungus first appeared in a soil mixture containing alfalfa meal and later in the mixture containing wheat straw. A soil suspension was used as inoculum and seems to be the most logical choice as a source. However, the alfalfa meal cannot be ruled out entirely, although the plants were subjected to 65° C for 24 hours before grinding.

This fungus would seem eminently suitable for physiological and nutritional studies of reproduction in the Basidiomycetes. There is at present, I believe, only *Agaricus campestris* available for such experiments as can be conducted with a compost medium.

Another point of interest is its drug producing potential. This genus has at least one species which has been described as producing a substance in the sporocarp that induces hilarity and intoxication, while another has been described as producing a substance poisonous to guinea pigs.

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[1] Professor A. H. Smith of the University of Michigan Herbarium at Ann Arbor, Michigan, has subsequently identified this fungus as *Coprinus fimitarius*. (*C. macrorhizus* sensu Kühner & Romagnesi).

Obviously, it may be used successfully as a teaching aid. Its ease of cultivation and sporulation insures this.

For convenience of access, we have deposited a culture with the American Type Culture Collection where it has been assigned the code number 12890.

CHEMISTRY

Chairman: Robert B. Fischer, Indiana University

E. T. McBee, Purdue University, was elected chairman for 1958

ABSTRACTS

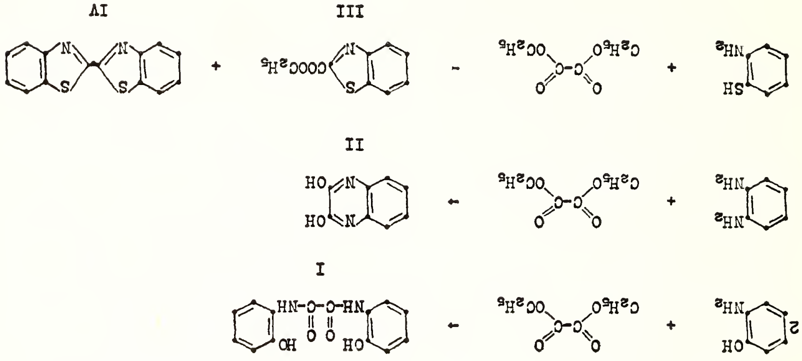
The Preparation of Some ω-Trifluoro-aliphatic Acids. E. T. McBee, C. W. Roberts and R. J. Kennedy, Purdue University.—A general synthesis for ω-trifluoro-aliphatic acids has been developed and has been applied to the preparation of ω-trifluorododecanoic and ω-trifluorotridecanoic acids. The method involves the free radical addition of trifluoromethyl iodide to the appropriate terminally unsaturated ester. The mode of addition was observed to proceed in analogy to the previously reported peroxide catalyzed addition of trifluoromethyl iodide to olefins. The iodine containing adduct need not be isolated for the subsequent reduction with zinc and acid. Acids of this type and their derivatives deserve interest because of their possible application as surface active agents.

Radical Addition of Hydrogen Bromide to 2,4,4-Trimethylpentene-2. V. J. Shiner, Jr. and Morris L. Smith, Indiana University.—A study of the addition of hydrogen bromide to 2,4,4-trimethylpentene-2 in the vapor phase promoted by acetone and ultraviolet irradiation showed that although the reaction had the characteristics of a radical chain process the product was essentially pure 2-bromo-2,4,4-trimethylpentone. This is the first published report of the radical addition of hydrogen bromide to an unsymmetrically substituted aliphatic olefin giving the "normal" product, the one also obtained by ionic addition.

Some Free Radical Additions to Perfluoro-1-heptene. E. T. McBee, G. W. R. Puerckhauer, C. G. Hsu, C. W. Roberts and L. R. Belohlov, Purdue University.—Though numerous free radical additions to gaseous perfluoroölefins are reported in the literature, little is known about the addition to higher boiling perfluoroölefins. In order to fill this gap and to gain further insight into the reactivity of this type of perfluoroölefins perfluoro-1-heptene was reacted with various common reagents.

Chlorine and bromine added readily under irradiation with UV-light. Bromotrichloromethane added less readily but gave still satisfactory conversions. Trichlorosilane which did not add to perfluoropropene under the same conditions, added to perfluoro-1-heptene to give tetradecafluoroheptyltrichlorosilane, of possible interest as a highly fluorinated alkyl silicone monomer. A series of agents such as carbon tetrachloride, carbon tetrabromide, chloroform and trifluoromethyl iodide could not be induced to react with perfluoro-1-heptene.

Reactions of Diethyl Oxalate with Ortho-substituted Anilines. E. Campaigne and J. E. Van Verth, Indiana University.—The mode of reaction of diethyl oxalate with aromatic amines substituted in the *ortho*-position with hydroxyl, amino, or mercapto groups was profoundly affected by the nature of the *ortho*-substituent. The type of product formed was completely different in each case.



The formation of ethyl 2-benzothiazolecarboxylate (III) from 2-amino-benzenethiol represents a new synthesis of this ester which accomplishes in one step what previously required four or more steps by way of the acid. Only $2,2^{1}$-bibenzothiazole (IV) had previously been isolated from this reaction; however a four-hour reflux in one-molar excess of diethyl oxalate produced 80% of III contaminated with a small amount of IV, readily separated by recrystallization. With *o*-aminophenol and *o*-phenylenediamine, in neither case could an oxazole or imidazole ester be isolated; the only products were *o*,*o*^{1}-dihydroxyoxanilide (I) and 2,3-quinoxalinediol (II), respectively. The addition of zinc chloride increased the rates of these reactions, but did not in either case change the nature of the product formed.

High-Speed Calculation of Least-Squares Best Consecutive Formation Constants of Metal-Ion Complexes Using an Electronic Computer

DONALD L. MCMASTERS and WARD B. SCHAAP, Indiana University[1]

Today, high-speed electronic computers are used in calculations that would be almost impossible and certainly impractical to do in any other way. In the field of chemistry, this applies mostly to the calculations involved in X-ray diffraction, electron diffraction, quantum mechanics, and so forth. Some of these calculations actually require many hours of electronic computer time.

There has been relatively little work done using computers for calculations which require much shorter periods of time, i.e., for problems requiring several tedious hours on a desk calculator. Electronic computers not only allow one to perform errorless calculations in the minimum amount of time, but also the use of electronic computers should encourage one to reconsider the basic equations used in his research to see whether or not he could use the more exact, but usually more mathematically complicated, fundamental equations to increase the accuracy of his results. This sometimes involves merely including more terms in the calculations or using more experimental data, or both. Also, certain statistical routines can usually be included to obtain the statistically best results.

As an example, in our research a least-square routine has proven to be a powerful tool in the calculation of the consecutive formation constants of inorganic complexes. This technique can be made applicable to other equilibrium processes in which it is desired to calculate all the equilibrium constants.

Let us consider an equilibrium process involving the consecutive addition of a group X to a central metal ion M. This can be represented in the following way:

$$M + X = MX \quad \text{where} \quad \frac{[MX]}{[M]\,[X]} = k_1 = K_1$$

$$MX + X = MX_2 \quad \text{where} \quad \frac{[MX]}{[MX]\,[X]} = k_2$$

$$\text{or} \quad \frac{[MX]}{[M]\,[X]^2} = k_1k_2 = K_2$$

etc.

For example, the metal ion may be Cu^{++}, Cd^{++}, Ni^{++}, etc., and the ligand, X, may be monodentate Cl^-, NH_3, pyridine, etc., or a polydentate ligand, X, may be monodentate Ce-, NH_3, pyridine, etc., or a polydentate number of four of these ligands can be coordinated to the metal ion.

The method to be discussed for the calculation of these formation constants involves the use of a power equation in which the coefficients of the variable are the overall formation constants of the complexes.

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[1] Contribution No. 816.

$$F_o(X) = k_o + K_1[X] + K_2[X]^2 + K_3[X]^3 + K_4[X]^4 \qquad (1)$$

This $F_o(X)$ function is calculated from polarographic data and includes the half-wave potential of the simple metal ion, the half-wave potential of the complexed metal ion and the ratio of the diffusion currents.

$$F_o(X) = \text{antilog}\left\{\frac{n}{0.0591}\left[(E_{1/2})_s - (E_{1/2})_c\right] + \log\frac{(I_d)_s}{(I_d)_c}\right\} \qquad (2)$$

This relationship involving polarographic data was first derived by DeFord and Hume in 1951 (1) by combining the Nernst equation with the Ilkovic equation and making simplifying assumptions concerning activities and concentrations of the various species in the region of the mercury drop.

The formation constants themselves are usually determined by a graphical technique. The graph of $F_o(X)$ versus the concentration of the complexing agent has an extrapolated zero intercept which is k_o, the formation constant of the zeroth complex. Of course, k_o has a theoretical value of 1.0 and this then serves as a check on the data. This value of the intercept is subtracted out and the result is then divided through by the concentration of the complexing agent to get a next lower order equation. This $F_1(X)$ function is then plotted versus the concentration of the complexing agent and the extrapolated zero intercept is the formation constant K_1 of the first complex, MX.

$$\frac{F_o(X) - k_o}{[X]} = K_1 + K_2[X] + K_3[X]^2 + K_4[X]^3 = F_1(X) \qquad (3)$$

This process is repeated until all the constants have been determined.

$$\frac{F_1(X) - K_1}{[X]} = K_2 + K_3[X] + K_4[X]^2 = F_2(X) \qquad (4)$$

$$\frac{F_2(X) - K_2}{[X]} = K_3 + K_4[X] = F_3(X) \qquad (5)$$

$$\frac{F_3(X) - K_3}{[X]} = K_4 = F_4(X) \qquad (6)$$

It is important to realize that there is an easily recognizable relation between the order of the F(X) equations (or the shapes of their plots) and the maximum number of complexes which can form. The last equation for the highest complex does not contain the concentration of the complexing agent and thus $F_4(X)$ should be a constant and independent of concentration. It can be considered a straight line horizontal to the concentration axis. The next to the last curve is a straight line of positive slope. The next lower curve represents a quadratic equation, the next a cubic and the last curve a quartic equation. (We are still assuming the presence of four complexes in the above discussion.)

Another point which should be mentioned is that the uncertainty in the values for the various constants increases as one goes from the first formation constant to the last. This is partly due to the uncertainty in the values of the extrapolated intercepts, since they are used in the later calculations, and partly due to the fact that the concentration of the complexing agent is reintroduced in each step of the calculations.

The obvious point to begin a least-squares calculation is with the $F_0(X)$ equation involving the formation of the zeroth complex, since the data involved in this calculation are the most accurate. Also, if the earlier constants can be calculated more accurately, since they are themselves used in the calculation of the rest of the constants, this will tend to increase the accuracy of the remaining constants.

Notice (Equation 1.) that the $F_0(X)$ equation contains all the constants. Theoretically, therefore, by solving for the coefficients of just this one quartic equation from the data by the method of least-squares, it should be possible to obtain all the formation constants directly. It will be explained later why this does not always work out in practice.

The least-squares routine (IBM 6.0.006) used in this work was originally programmed for the IBM 650 by a research group at General Electric and is made available to users of IBM 650's throughout the country by a central library maintained at the headquarters of the IBM Data Processing Division.

This routine requires about two minutes to calculate all the least-squares best coefficients for the linear, quadratic, cubic and quartic equations for any number of data points up to 100. That is, the program is set up to try automatically all four orders of equations with each set of supplied data. It also calculates y values for each given x value using the least-squares best coefficients in each order equation. These last data are useful in estimating the standard deviations of the results. The experimental data to be considered as an example in this discussion are from an actual metal-ion complex system and the authors are indebted to Mr. Frank A. Guthrie for his permission to use his data in this paper.

The procedure is straightforward. The values of $F_0(X)$ and $F_1(X)$ at different concentrations of the complexing agent are calculated according to equations (2) and (3), respectively. These functions are then first plotted graphically versus the concentration of the complexing

TABLE I

Calculated Least-Squares Coefficients for F (X) *vs.* [X] Data Assuming Linear, Quadratic, Cubic and Quartic Equations.

Data	Equation Type	Coefficients (Formation Constants): k_0	K_1	K_2	K_3	K_4
$F_0(X)$	linear	0.3573	46.21			
	quadratic	0.9706	21.56	157.5		
	cubic	0.9860	20.52	173.8	–68.44	
	quartic	0.9157	27.82	–29.85	1937	–6358
$F_1(X)$	linear		16.58	215.7		
	quadratic		20.47	144.8	171.8	
	cubic		21.19	115.9	357.9	–299.0
$F_2(X)$	linear			145.4	178.6	
	quadratic			121.6	249.0	–36.31
$F_2(X)$	linear (constant)				174.4	3.723

agent to obtain an approximate value of the extrapolated zero intercept for k_o and K_1, respectively. (k_o should theoretically be 1.0 and in our example K_1 is approximately 20.) The $F_o(X)$ data are then used in the IBM 650 least-squares routine. The results of the least-squares calculation of the $F_o(X)$ data are then checked to see how the k_o and K_1 constants agree with the graphically extrapolated values of 1.0 and 20. The value of K_2 should also be noted and kept for future comparisons.

Assuming that four complexes are present, k_o and K_1 should fit the least-squares coefficients of the quartic equation best. The least-squares results for the quartic equation indicate that k_o is 0.9157 and K_1 is 27.82. (See Table I.) However, if we consider the results of all the least-squares calculated coefficients, we see that the values for k_o and K_1 of the cubic equation approach the expected values more closely. (The value of K_2 is also more reasonable.) Therefore, we may begin to suspect that only three complexes are formed.

This, then, is an important step of the procedure: If the graphically extrapolated values of k_o and K_1 fit the least-squares coefficients of the quartic equation best, then there will be four and only four complexes. If the values fit the cubic coefficients best, then only three complexes are formed; if the quadratic coefficients fit best, then only two complexes are indicated; and if the linear gives the best fit, then only one complex is indicated.

In our example, k_o and K_1 fit the cubic equation best and therefore only three complexes are indicated. Furthermore, the results of the next calculation can also be used to support this. When the $F_1(X)$ data are used in the least-squares calculation, the results indicate that these data best fit a quadratic equation with a value of 20.47 for K_1. (See Table I.) This then confirms the fact that only three complexes can be present since a next lower order equation is theoretically expected and the values of the constants check with the graphical results. The quadratic coefficients for the $F_1(X)$ data give 144.8 for K_2 and 171.8 for K_3.

The calculations can then be continued with a definite knowledge of the shapes of the remaining curves and also the approximate values of the remaining constants. In our example, there are only two more lines. One of these is linear and the other is constant (i.e., horizontal). The intercept coefficient, K_2, obtained from the linear equation coefficients calculated from the $F_2(X)$ data by the least-squares method is 145.4, which agrees well with the value of 144.8 obtained from the K_2 coefficient of the quadratic equation for the $F_1(X)$ data. The K_3 coefficient of the quadratic $F_1(X)$ equation is 171.8; the K_3 coefficient from the linear $F_2(X)$ equation is 178.6. Both of these agree well with the intercept coefficient, $K_3 = 174.4$, for the approximately horizontal $F_3(X)$ line. However, in this case it is undoubtedly better to use an average of the constant values of $F_3(X)$ rather than the intercept value, for there is no point in magnifying any false trend in the supposedly constant values of $F_3(X)$ by extrapolating to zero concentration. The mean value for $F_3(X)$ is 177.3, and we shall take this as the statistically best value for K_3. Ideally, since K_3 is the formation constant of the highest complex, the value of K_4 should be zero. Actually, the values of K_3 from the $F_3(X)$

calculations do exhibit a slight slope and the least-squares best value of K_4 is 3.7, which is certainly close enough to zero to be within the limits of experimental error.

Estimation of the standard deviations of the various coefficients of the polynomial equations is a fairly complex statistical problem and will not be discussed here. Since values of the lower coefficients are used in calculations of the higher coefficients, the errors will be cascaded.

It was mentioned previously that it should be possible in theory to obtain all the values of K_n, the formation constants, from the least-squares best coefficients of the $F_o(X)$ data, but that this did not work out in actual practice. The reason for this is that certain 'assumed constants' such as activity coefficients and liquid junction potentials are not actually constant, but gradually change when the concentration of the complexing agent changes. These changes in 'assumed constants' cause the half-wave potential to shift. But since the total observed half-wave potential shifts are used in calculating the formation constants, the apparent values of these formation constants will be different when calculated from data in widely different concentration regions. Self-consistent and concordant results are obtained only when data in a more limited concentration range are used in the calculations This then serves as an explanation for the disagreement in the values of the higher least-squares coefficients in the $F_o(X)$ calculation and the final calculated results.

We have chosen to include data only from concentration ranges where a particular complex is present in significant amounts in the calculation of the formation constant of that complex. Thus, only the data from the ten lowest concentrations were used in the final calculations of k_o. Data from the lowest fourteen concentrations were used in the final calculation of K_1, while data from the eleven most concentrated solutions were used in the final calculation of both K_2 and K_3.

Another point also becomes obvious when one applies a statistical treatment to data from which a number of constants are to be evaluated. This is that a larger amount of raw data (in this study, half-wave potentials at a given concentration of complexing agent) should be used than are usually used in making such calculations. For example, half-wave potentials at six different concentrations would provide only two degrees of freedom if four independent constants are to be evaluated, so the results would show relatively large standard deviations. In most published applications of this method, a total of only about eight to ten points are used, which certainly would be the minimum acceptable, even if all points were used in the calculation of all the formation constants, which is normally not the case. In the results discussed here 21 concentrations are used and at each concentration the half-wave potential is the average of at least four and sometimes five or six half-wave potentials. We feel, then, that our results are relatively statistically reliable.

In summary, the reliability of calculated consecutive formation constants of complexes can be greatly increased by applying statistical techniques. The use of electronic computors allows the necessary calculations to be made quickly and easily and thus encourages application of mathematical relationships that would not ordinarily be used because of the great amount of time that would be involved in doing the same calculations with a desk calculator.

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High-Speed Calculation of Least-Squares Best Half-Wave Potentials and Slopes of Polarographic Waves Using an Electronic Computer

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The fundamental equation which describes the polarographic wave (1) for the reversible reduction of a hydrated metal ion to a soluble, dilute amalgam is

$$E_{dme} = E_{1/2} + \frac{RT}{nF} \ln \frac{i_d - i}{i},$$

where E_{dme} refers to the potential of the dropping mercury electrode at some point on the wave at which the current is i, and i_d as the diffusion limited current. The half-wave potential, $E_1/_2$, is a constant of thermodynamic significance and is independent of concentration.

In most electrochemical research involving polarography, the half-wave potentials and slopes of the waves are desired experimental quantities and various techniques have been used to obtain these quantities. Approximate values of half-wave potentials and slopes may be obtained by the simple technique of drawing a line along the residual current portion of the wave, drawing another line parallel to this one along the diffusion portion of the curve and then dividing the distance between these two lines to obtain the half-wave point. The potential at this point is the $E_{1/2}$. The potential difference between the ¼ and ¾ points on the wave is equal to 0.954(0.0591/n), from which the usual slope can be calculated.

A mathematically more precise procedure of obtaining the half-wave potential is to plot E_{dme} vs. log $(i_d - i)/i$ using values of E_{dme} and i from the rising portion of the polarographic wave. This plot theoretically should be a straight line from which the $E_{1/2}$ can be read off at the point where the log $(i_d - i)/i$ term is zero, i.e., the zero intercept. The slope of this line has significance because it is equal to 0.0591/n at 25°C, where n is the number of electrons involved in a polarographically reversible reduction.

The statistically best method is to fit the E_{dme} and log $(i_d - i)/i$ data to a straight line of the type $y = a_1 + a_2x$ by the method of least-squares. The constant a_1 is the zero intercept, i.e., the half-wave potential, and a_2 is the slope of the best straight line. To do this calculation completely on a desk calculator would probably take at least 30 minutes apiece. To prepare the graph even on semi-log graph paper requires about ten minutes apiece. For optimum efficiency and accuracy, the least-squares best half-wave potential and slope can be calculated on a high-speed electronic computer. In our case an IBM 650 Magnetic

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[1] The authors are indebted to the Research Computing Center at Indiana University for providing time on the IBM 650 computer for the purpose of preparing this program. Contribution No. 815

Drum Calculator and 'Bell Labs Code' were used in making such calculations. (The calculator is located at the Research Computing Center at Indiana University.)

The overall time necessary to transfer the data from the polarogram to special mimeographed sheets (designed to increase the speed and accuracy of punching the IBM data cards), then punch the cards, perform the machine calculation and tabulate the answers, amounts to four minutes per polarogram. Of these four minutes only 15 seconds are used by the electronic computer for each calculation. One other important feature of the program is that both the half-wave potential and slope are corrected for the resistance of the set-up.

Procedure for Tabulation of Data

This program has been designed for polarograms recorded by the Sargent Model XXI Visible Recording Polarograph, but with only a few obvious and minor changes this program can be adapted to other manually and automatically recorded polarograms.

During the process of actually recording the polarogram, the investigator should record (preferably directly onto the polarogram) the sensitivity setting of the polarograph (μa/mm.); the cell resistance as measured with a resistance bridge (ohms); the resistance of the measuring resistor at the given sensitivity (ohms)[1]; two calibrating voltages measured with a potentiometer, one measured before the wave and one after the wave (volts); and finally the polarogram number.

The following method of obtaining the remaining data from the curve is recommended for convenience:

(1). Draw a straight line along the top of the residual current curve.

(2). Draw a straight line parallel to this along the top of the diffusion current curve.

(3). Number consecutively 5,6,7 or 8 d.m.e. pips in the middle part of the rising portion of the polarogram. It makes no difference whether these pips are numbered starting from the bottom or the top. (The program was set up to use up to a maximum of eight current-voltage points in making the calculations.)

After these steps have been performed, all the necessary data may be tabulated on special mimeographed sheets. The general form of this sheet is shown in Table 1. All numbers must be recorded in 'floating decimal' form. The number occupies the first eight digits of a ten-digit word and the exponent occupies the last two. The exponent is simply 50 plus the exponent of base 10. For example, $543.21 = 5.4321 \times 10^2$ and hence is written 5432100052; $0.00543 = 5.43 \times 10^{-3}$ and is written 5430000047. (Zero is given a zero exponent, hence all ten digits are zero.)

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[1] Since reasonably precise calculations are being made, the half-wave potential must be corrected for the total resistance through which the current passes. This resistance is the resistance of the cell (measured with a resistance bridge) plus the resistance of the measuring resistor of the sensitivity unit. This resistance is different for each sensitivity setting and can be obtained from the manufacturer's instrument manual.

If less than eight points are used, the data must be tabulated starting from the top of the data sheet and the unused data positions must be filled with numbers of some sort (usually zeros) for the entire routine to operate correctly.

The E_{dme} terms are tabulated not as voltage, but in % divisions starting from the initial voltage point. The program converts % divisions into applied voltage.

The i terms are tabulated not in units of current, but are recorded in units of mm. distance from the residual current line. Again, it is not necessary to convert to current since the program performs the necessary conversions.

The constants are tabulated thus: the diffusion current in mm., the sensitivity in amps./mm. (not in μamps./mm.), the total resistance in ohms (which is the sum of the cell resistance and the resistance of the measuring resistor at the sensitivity used), the two calibrating voltages in volts, the number of voltage divisions between the initial and final voltage in % and the number of d.m.e. pips used, expressed in two different forms. (One form of this number is in the form of an instruction with only the last three digits actually to be used in the program i.e., 0 000 000 00j. The second form is written in floating decimal form as j000000050, which is used in the least-squares portion of the routine as the number of points used.)

The polarogram number follows each group of data so that the number is on each data card. A test routine in the program checks these numbers to be sure that all the data it is using for each calculation are from the same polarogram.

TABLE 1

Data Sheet for Polarographic Data

Data Locations	Voltages	Currents	Constants	
100	E_1	i_1	i_d	Pol. No.
104	E_2	i_2	sens.	Pol. No.
108	E_3	i_3	resistance	Pol. No.
112	E_4	i_4	init. E	Pol. No.
116	E_5	i_5	final E	Pol. No.
120	E_6	i_6	voltage div.	Pol. No.
124	E_7	i_7	no. of data	Pol. No.
128	E_8	i_8	no. of data	Pol. No.

Block Diagram of the Program

Any mathematical program designed for an electronic computer is based on two fundamental types of processes. One process involves the use of the ordinary mathematical calculations (add, subtract, multiply and divide, and computation of logarithms, sines, etc.), the other involves the use of logical operations, i.e., having the machine read and store the program and data, set-up certain instructions, punch out the results, etc. In general, the mathematical operations are located in the middle of the program with the logical operations both preceding and following the mathematical operations.

This half-wave potential program is written in 'Bell Labs Code'. This code is a Complete Floating-Decimal Interpretive System which transforms the IBM 650 into a three-address, floating-decimal, general-purpose computer. The system is complete in the sense that all mathematical, logical and input-output operations normally called for in such calculations can be performed within the system, i.e., without reference to the basic operation codes of the IBM 650.

The magnetic drum which is the heart of the machine has 2,000 locations which have location addresses numbering from 0000 to 1999. The Bell Labs interpretive routine requires the use of the last 1,000 locations for its operations; this leaves the locations from 0000 to 0999 available for computing purposes. Either instructions or data can be stored in any of these latter locations.

The half-wave potential program can be summarized conveniently in the following block diagram form:

READ DATA

The machine reads the eight data cards and stores the information into consecutive drum locations from 100 to 131.

MOVE DATA

The data are then moved to "more convenient" locations for ease in programming the calculations. For example, the i values are moved to consecutive locations so that the LOOP BOX can be used. A LOOP is any series of calculations involving a repetition of a mathematical procedure, but which uses different numerical values each time the mathematical procedure is repeated. For example, the term $\log(i_d - i)/i$ has to be calculated for each value of i. The calculation is done with the first value of i, then the LOOP BOX has the computer to repeat the calculation using the next value of i. This is repeated until all the values of i are used.

SET LOOPS

In this step the LOOP instructions have to be set for the number of times these calculations are to be performed. Since a variety of the number of d.m.e. pips are used in the calculations, the LOOP orders have to be modified to loop just as many times as there are d.m.e. pips. This is the portion of the program where that "number of data" in the form of an instruction is used.

TEST POLAROGRAM NO.

This routine checks the polarogram number from each card to be sure the data are from the same polarogram. (This is accomplished by subtracting the second number from the first number. If the answer is *not* zero the machine will stop and the cards have to be corrected. If the answer is zero, the routine continues by subtracting the third number from the second number, etc.)

iR AND INIT. E CORRECTIONS

The voltage terms, which are actually in units of chart divisions, have to be converted to voltage using the initial and final voltages and the chart divisions between these two points. Next, the initial voltage is added to each voltage term. These voltages are then corrected for iR drop by adding on the iR correction.

LOG$(i_d - i)/i$ CALCULATION

The other set of coordinates needed for the least-squares calculation is the series of $\log(i_d - i)/i$ terms. These are calculated for each value of i and then the results are used in the least-squares calculations along with the appropriate E_{dme} values.

LEAST-SQUARES CALCULATION

The least-squares procedure calculates the two statistically best constants of the linear equation

$$E_{dme} = E_{1/2} + (0.0591/n) \log(i_d - i)/i.$$

The rest of the program involves performing this least-squares calculation.

PUNCH ANSWERS

The final step of the procedure is the punching-out of the answers.

The computer automatically punches out the results on IBM cards. These tabulated results include the polarogram number, half-wave potential and slope, all on one card, the corrected E values (in volts) on two cards and the $\log(i_d - i)/i$ terms for each value of i on the last two cards. These latter two sets of data are punched-out so that if it is desired the half-wave potential and slope can be checked by plotting these data manually.

In summary, the high-speed calculation of the least-squares best half-wave potentials and slopes of polarographic waves using an electronic computer can be accomplished very efficiently to give useful and accurate results.

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A Method of Calculating the Heats of Combustion of Organic Compounds

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A simple method of calculating the heats of combustion of organic compounds is most useful to the practical chemist. In a previous paper (1) six specific equations have been given for calculating the heat of combustion of as many types of organic compounds. These equations are all based on the number of oxygen atoms, s, necessary to burn the compound to $CO_2(g)$ and $H_2O(1)$. All oxygen in the compounds is used except the oxygen in the NO_2 group of nitrocompounds. The equations given previously are,

(1) $-Hc = 52.48\ s + 6$, for alkanes
(2) $-Hc- = 52.48\ s + 20$, for alkenes
(3) $-Hc = 52.48\ s + 43.3$, for alkynes
(4) $-Hc = 51.8\ s$, for amides
(5) $-Hc = 52.4\ s$, for aromatics
(6) $-Hc = 50.3\ s$, for nitrocompounds.

All of the equations given in this paper are based upon the reactant in its normal state at 25°C and 1 atm. and the answers are in kcal/mole.

The accuracy of these equations and the simplicity of the method warrants their extension to other types of compounds. Data recorded by Kharasch (2) for organic fluorine compounds fit the equation.

(7) $-Hc = 53.85\ s$,

if the organic fluorine compounds are burned to $CO_2(g)$, $H_2O(1)$ and $HF(g)$. Equation (7) does not apply to compounds containing carbon and fluorine only (3, 4). Data on chlorohydrocarbons by Smith (5) and Waddington (6) are best given by

(8a) $-Hc = 53\ (s-0.5)$,

for compounds without oxygen and by,

(8b) $-Hc = 52.2\ s$,

for the CHOCl type compounds. The chlorine is converted to $Cl_2(g)$.

The bromine compounds listed in Kablukov's (7) and Kharasch's papers fit the equation,

(9) $-Hc = 50.6\ s$,

if $Br_2(1)$ is the final form of the bromine. Likewise for the iodine compounds given by Kharasch (2) the equation,

(10) $-Hc = 54\ s$,

holds if $I_2(s)$ is produced.

Again using the data collected by Kharasch (2) and by Parks (8) and co-authors we find the following equations for aliphatic alcohols, aldehydes, acids, amino acids and ethers respectively.

(11) $-Hc = 51.64\ s + 18$ (alcohols)
(12) $-Hc = 53.3\ s + (?)$ (insufficient data on the aldehydes)
(13) $-Hc = 51.85\ s$ (aliphatic acids)
(14) $-Hc = 52.5\ s$ (amino acids)
(15) $-Hc = 52.5\ s + 30$ (aliphatic ethers)

It is readily seen that the heat of combustion of hundreds of organic compounds are given by the equation,

$$-Hc = Ms + b, \qquad \text{(kcal/mole)}$$

where M is 52.5 ± 2 and b varies from 0 for aromatic compounds and amino acids to 43 for alkynes. The constant M could be given with less variance except for the lowest molecular weight members of a series. The large values of b in the alkene and alkyne equations are undoubtedly due to the unsaturated compounds being unstable. However, with these exceptions the equation,

$$-Hc = 52.5\ s$$

will give heats of combustion data accurate enough for all types of chemical work where factors such as heat transfer, radiation losses, etc., are involved. It is accurate enough to distinguish between $\triangle E$ and $\triangle H$. This equation is not simply three times the heat of combustion of $-CH_2-$, with the heat of formation of $-CH_2-$ neglected. Our calculated value is within 1% of the correct answer for CH_3COOH(1), yet the heat of formation of acetic acid is over 50% of the value of its heat of combustion.

The fact that one simple equation will give results within a few per cent of accurate experimental data, regardless of the number of CO_2 molecules produced per one mole of H_2O, and regardless of the number of kind of bonds broken, or the position of a group in the molecule, indicates that the theoretical work on bond energies based upon thermochemical data needs further investigation.

The mechanism given by Lewis and von Elbe (10) for the combustion of methane led us to break up the oxidations of the various types of compounds into steps. Since the heat liberated in many of these processes is so near 105 kcal per mole of oxygen used, these stepwise processes may be the physical significance of the constant 52.5. The only radical exception to this hypothesis involves data on HCHO(g) and therefore its heat of combustion is being experimentally determined in our laboratory. In order to show this relationship let us consider the following classes of compounds. All calculated values in this theoretical discussion use the general equation $-Hc = 52.5\ s$ and not the specific equations since we are trying to show the origin of M.

Alkanes:

It is impossible to discuss each alkane. It is sufficient to use two, CH_4 and C_3H_8. CH_4 is chosen because it does not fit our equation well.

The experimental value (6) is –212.80 and our calculated value is –216.0 kcal/mole. (All data from reference 11)

(a) $CH_4(g) + OH = H_2O(1) + CH_3$
$CH_3 + O_2 = HCHO(g) + OH$

$CH_4(g) + O_2(g) = HCHO(g) + H_2O(1) \quad \triangle H = -78.11$ kcal
(b) $HCHO(g) + O_2(g) = CO_2(g) + H_2O(1) \quad \triangle H = -134.67$ kcal

The summation of equations (a) and (b) gives the complete combustion of CH_4 and –212.78 kcal, or an average of 53.2 kcal/atom of oxygen converted to H_2O and/or CO_2.

If the H_f of formaldehyde agreed with the one calculated using our Hc, equation (a) would be –107.8 and (b) –105.0 kcal. It does not agree with calculated results using bond energies either. Most values for the C=O[12,13] bond are taken from the heat of combustion of formaldehyde.

$C_3H_8(g) + O_2 = CH_3COCH_3(1) + H_2O(1) \quad \triangle H = -95.285$ kcal
$C_3H_8(g) + O_2 = C_2H_5CHO(1) + H_2O(1) \quad \triangle H = -95.88$ kcal
$C_2H_5CHO(1) + O_2 = C_2H_5OH(1) + CO_2(g) \quad \triangle H = -107.5$ kcal
$C_2H_5OH(1) + O_2 = CH_3COOH(1) + H_2O(1) \quad \triangle H = -117.36$ kcal
$CH_3COOH(1) + O_2 = CO_2(g) + H_2O(1) + HCHO(1)$
$\triangle H = -103.34$ kcal
Average $\triangle H = -106.02$ kcal/O_2.

Each of these five steps assumes an intermediate peroxide. The experimental Hc of C_3H_8 is –530.6 and equation 1 gives –530.8 kcal. Note that aldehydes, ketones, alcohols and acids are included in these processes even though they usually fit the general equation very poorly.

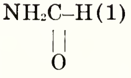
Halohydrocarbon:

$CH_2Cl_2(g) + O_2 = \text{peroxide} = COCl_2(g) + H_2O(1) \quad \triangle H = -100.62$ kcal.
$\triangle H_{(calc)} = -105$

$$2CH_2ClCH_2OH(1) + \frac{11}{2} O_2 = 4\,CO_2(g) + 5\,H_2O(1) + Cl_2(g)$$

$\triangle H = -577.2$ kcal.
$\triangle H_{(calc)} = -577.5$ kcal.
or 105 kcal/O_2

Amino Acids:

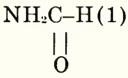


$NH_2CH_2COOH(s) + O_2 = CO_2(g) + NH_2\underset{\overset{||}{O}}{C}\text{–}H(1) + H_2O(1)$
$\triangle H = -99.6$ kcal
$\triangle H_{(calc)}$–105.0

$NH_2C_2H_4COOH(s) + O_2 = CH_3CONH_2(1) + H_2O(1) + CO_2(g)$
$\triangle H = -99.52$
$\triangle H_{(calc)} = -105$ kcal

$NH_2C_5H_{10}COOH(s) + O_2 = C_4H_9CONH_2(1) + CO_2(g) + H_2O(1)$
$\triangle H = -101.82$
$\triangle H_{(calc)} = -105$ kcal

Amides:



$NH_2\underset{\overset{||}{O}}{C}\text{–}H(1) + 5/4\,O_2 = CO_2(g) + 1/2\,N_2 + 3/2\,H_2O(1)$
$\triangle H = -134.9$ kcal.
$\triangle H_{(calc)} = -131.25$
or 105 kcal/O_2 used

Benzene Series:

$$2\,C_6H_6(1) + O_2 = 2\,C_6H_5OH(1) \qquad \triangle H = -102.4\text{ kcal.}$$
$$C_6H_6(1) + O_2 = C_6H_4(OH)_2(s) \qquad \triangle H = -105.0\text{ kcal.}$$
$$2\,C_6H_6(1) + 3\,O_2 = 2C_6H_4O_2(s) + 2\,H_2O(1) \qquad \triangle H = -102\text{ kcal.}$$

The next step in the process is apparently a complete breakdown of the ring to give CO_2 and H_2O. The experimental $\triangle H$ for the combustion of benzene is –787.2 kcal and our calculated value is –786.0.

Alkenes and Alkynes:

Lewis and von Elbe (10) make the statement, "the oxidation of acetylene appears to be unrelated to the reaction in other hydrocarbon-oxygen systems." They give mechanisms for ethylene involving HCHO and $\underset{\underset{O}{\triangledown}}{H_2C{-}CH_2}$. These mechanisms do not substantiate our theory. Mechanisms for ethylenes which involve $(HCOH)_2$, $(HCO)_2$ and $(COOH)_2$, etc., necessitate a value of b equal to 20 in equation (2). If the heat of formation of alkenes and alkynes were negative instead of positive, i.e. if they were in a lower energy state, this discrepancy would not occur. Apparently we are not starting with them in a ground state comparable to the other hydrocarbons. The same difficulty occurs with the lowest molecular weight members of any series.

Bond energies (12) are discussed so much by organic chemists and chemists working on molecular structure that we are including here examples of heats of combustions calculated using bond energy data (13) and a new set of bond energies based upon thermochemical data given by Rossini (11).

In discussing the equation –Hc = 52.5 s, Glasstone[12] says, "A more fundamental approach to the problem of calculating heats of formation and reaction is by the use of bond energies." The futility of bond energies is exemplified by the fact that the heats of combustion of aliphatic acids are almost identical to the heats of combustion of alkanes with one less carbon. The same is true for amino acids and the corresponding amines; i.e., splitting out CO_2 absorbs about 1 or 2 kcal. The heat of combustion of glycols is almost the same as the heat of combustion of the product which remains after water is split out. Examples are:

(Kharasch's[2] Data)

	$\triangle H$		$\triangle H$
CH_3COOH	–209 kcal.	$CH_2(COOH)_2(s)$	–206.5
CH_4	–210.8	$CH_4(g)$	–210.8
C_2H_5COOH	–367.2	CH_2OHCH_2OH	–281.9
C_2H_6	–368.4	CH_3CHO	–279.0
C_3H_7COOH	–524.3	$CH_3CHOHCH_2OH$	–431.0
C_3H_8	–526.3	CH_3COCH_3	–430.8

Bond energies are not usable unless the correct structural formula is known. The calculations are slow and tedious. We feel that the bond energies given in Table II are more useful than those given by Glasstone (13) since we do not have to consider resonance. Bond energies cannot be meaningful except in the case of two univalent elements, i.e., the value of a C-H bond must depend on what is sharing the other 3 valences of carbon. Table I shows that the equation, $-Hc = Ms + b$ is as accurate as any system of bond energies. There are too many types of bonds for the method of bond energies to be used generally. The nitrocompounds are a striking example. The values we list are energies liberated when the two elements unite to form the bond. We do not think it is plausible for the C—C bond to have a negative value unless other elements are joined to each carbon. How can the $C{=}C$ bond be more stable than the C—C bond (see Glasstone's values)? How can the $C{\equiv}C$ be more stable than the $C{=}C$ bond? We give the values of $H_2O(1)$ and $CO_2(g)$ since they occur in every calculation and as the data show, joining two hydrogens to oxygen is not twice the value of joining one. Likewise our C—H bond is one-fourth the heat liberated when CH_4 is formed from C and 4 H's and will have little value in CH_2F_2, $CH_2(NO_2)_2$, etc.

The combustion of carbon compounds in many cases is a cyclic process, $\text{compound}_1 + O_2 \longrightarrow \text{intermediate} \longrightarrow \text{compound}_2 + H_2O$ and/or $CO_2 + 105$ kcal. Then the stepwise process repeats until CO_2 and/or H_2O are the ultimate products with 105 kcal liberated for each mole of oxygen consumed. This leads to the general equation,

$$-Hc = 52.5\ s, \qquad \text{(kcal/mole)}$$

for the heat of combustion of carbon compounds.

TABLE I

Compound	Hc(expt)	Hc(calc)$_1$	Hc(calc)$_2$	Hc(calc)$_3$
$C_2H_2(g)$ (acetylene)	–310.6	–305.8	–309.0	–301.8
$C_2H_4(g)$ (ethylene)	–331.6	–335	–314	–311.6
$CH_3COOH(1)$ (Acetic acid)	–209.4	–207.5	–211.35	–198.1
$C(NO_2)_4(1)$ (tetranitromethane)	–102.9	–100.6	–41.7	
$C_6H_6(1)$ (benzene)	–787.2	–787.5	–804	–760.6
$CH_2Cl_2(g)$ (dichloromethane)	–134.3	–132.5	–139.8	–130.6
$NH_2CH_2COOH(s)$ (glycine)	–234.0	–236.1	–235.5	–235.1
$HCONH_2$ (formamide)	–134.9	–129.5	–140.0	–121.8
$C_6H_{14}(1)$ (hexane)	–990.0	–1003.0	–1015.5	–928.6
$HCHO(g)$ (formaldehyde)	–134.1	–106.6	–106.1	–134.8
$C_7H_{15}F(1)$ (N-heptyl fluoride)	–1121.5	–1130.8	–1088.6	
$C_2H_5OH(1)$ (ethyl alcohol)	–327.6	–328.0	–327.6	–315.9
$C_2H_4ClOH(1)$ (monochloroethanol)	–288.6	–287.1	–290.2	–274.4

$_1$—Equations this paper, $_2$—our bond energies, and $_3$—Glasstone's bond energies.

This table includes a wide variety of structures and bond types. If Hc can be calculated without cognizances of structure, bond angle, or bond length, then the authors feel that heats of combustion data cannot be used to show bond structure or bond energies?

TABLE II

Bond Energies of Formation

C—C	+ 7.5		H—Cl	—103	
C=C	+ 23.6		H—Br	— 87.46	
C≡C	+ 42		H—I	— 71.38	
C—F	— 59.0		H—H	—104.2	
C—Cl	— 35.5		O=O	—118.3	
C—Br	— 71.38		O—H	—101.3	
C—I	— 12.0		H_2O(1)	—231.7	
C—H	— 56.75		CO_2(g)	—212.4	
C—O	— 60	(alcohols, acids, esters)	N≡N	—171.2	
C=O	— 94.0	(ketones)	N=O	— 90	(nitro)
C≡O	— 86.0	(CO gas)	F—F	— 36.6	
C=O	—106.2	(aldehydes, acids)	Cl—Cl	— 58	
N—H	— 78.7		Br—Br	— 53.4	
C—N	— 37		I—I	— 51	
H—F	—134.6		N—F	— 55	

(Values given are kcal liberated at 25°C when the bonds are formed; i.e., H + H = H — H and △H is —104.2 cal. meaning a stable union.)

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Aging of Reagent Solutions in Precipitation Processes

ROBERT F. BABCOCK[1] and ROBERT B. FISCHER, Indiana University

Introduction

The effect of the length of time during which a solution of barium chloride is allowed to age, prior to its use, upon the particle size of precipitated barium sulfate has been investigated by Bogan (1), (2) and by Fischer and Rhinehammer (3). Both found that barium sulfate crystals precipitated from a fresh solution of barium chloride are smaller than those from an aged solution. Bogan also found that filtered, fresh barium chloride solutions produced larger barium sulfate particles than did unfiltered, fresh solutions. Fresh solutions prepared from finely ground barium chloride resulted in small particles, while a solution prepared from one large barium chloride crystal gave larger particles. Bogan concluded that a fresh barium chloride solution had undissolved barium chloride particles present which acted as additional nuclei. Presumably filtration would remove these particles by adsorption, and aging by a combination of adsorption and dissolution.

Rhinehammer investigated the effects of the previous history of the water used to prepare the solution and the container in which the solution was aged. All combinations resulted in larger particles with an aged solution than with a fresh solution, but the magnitude of the effect varied widely. It was noted that precipitates prepared from still older solutions consisted again of small particles; this observation is not compatible with Bogan's theory. Benedetti-Pichler (4) ascribed the aging effect to impurities in the barium chloride which are adsorbed on the container on aging. He found that a fresh solution of recrystallized barium chloride produced large particles, but other workers have observed the aging phenomenon even with highly purified barium chloride. This explanation also fails to explain the production of small particles from still older solutions.

The purpose of the present study was to investigate further this aging phenomenon using a variety of experimental methods. An attempt was made to obtain further experimental data, either to support or to reject previously proposed explanations. An attempt was also made to ascertain whether or not a similar phenomenon occurs with other solutions and in other precipitation processes.

Experimental

1. Effect of Filtration

Precipitations of barium sulfate were made with both fresh and aged solutions of barium chloride and also with solutions which had been filtered when fresh and then aged. The barium chloride solution was 0.02 molar. The sodium sulfate solution was 0.016 molar, with the pH adjusted to 1.0 with hydrochloric acid. The mixing of equal volumes of solutions resulted in a twenty-five percent excess of barium ion. Average particle sizes of barium sulfate were determined by measurement with a light microscope equipped with a micrometer eyepiece.

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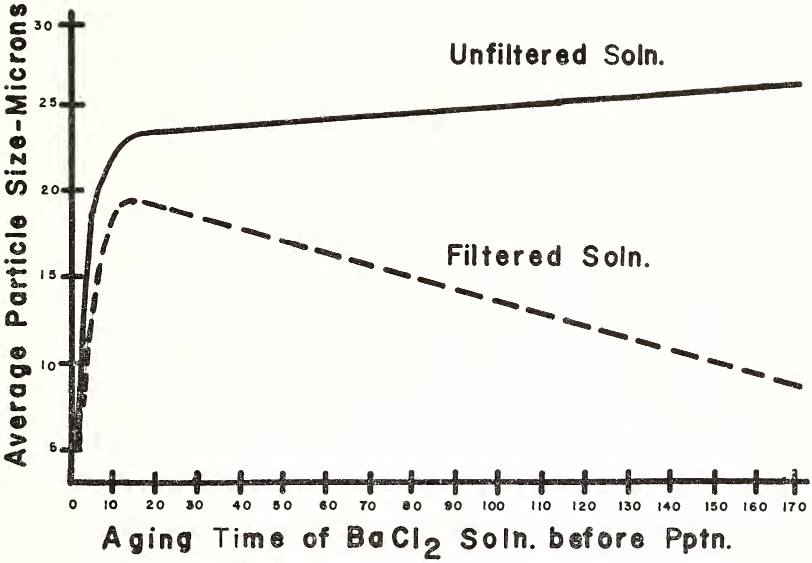
[1] Present address: Standard Oil Co. of Indiana, Whiting, Ind.



hours

Figure I.

Typical results are shown in figure 1. The solid line represents data for a barium chloride solution which was aged without filtration. The broken line represents data obtained with a barium chloride solution which was filtered when fresh and then aged. A projection of the solid line to an aging time of one month indicates a decrease in size to seven microns. Barium chloride solutions which had aged for long periods of time produced two sizes of particles. This could be due to particles forming both by spontaneous nucleation and from nuclei of impurities, perhaps dissolved from the walls of the container.

The effect of filtration appears to be one of speeding up the complete cycle of the aging process rather than one of eliminating the phenomenon. The data of figure 1 are for filtration through a sintered porcelain crucible; filtration through filter paper and a Seitz bacteriological filter produced similar results.

In other experiments a Bausch and Lomb Spectronic 20 spectrophotometer was used to measure optical density of suspensions of the precipitate in its mother liquid. The optical density should be a direct function of the total surface area of the precipitated particles, and this in turn should be an inverse function of average particle size. This procedure should give a more representative measure of average particle size than the direct microscopic measurement. The two methods did, however, compare favorably with each other.

2. Effect of Mixed Solutions

It was thought that perhaps nuclei present in a barium chloride solution would result in the formation of large particles of barium sulfate rather than small ones. That is, the barium sulfate crystals would form around these "seeds," and particles resulting from spontaneous nucleation would be negligible. If this were the case then an aged barium chloride solution, which results in large barium sulfate particles, should contain more nuclei than a fresh solution. To test this supposition mixtures of half fresh and half aged barium chloride solutions were used to precipitate barium sulfate. Average particle sizes were determined both by microscopic and by spectrophotometric measurement. All particles formed were of small, uniform size, no matter how old the aged half of the barium chloride solution. This result indicates that the fresh half of the solution controls the size of the particles. Since these are all small, the fresh solution must contain the additional nuclei which cause the small particles. Therefore the above supposition appears to be disproved.

3. Induction (Nucleation) and Growth Periods

The study of both the induction and growth periods for barium sulfate precipitation was undertaken. Fresh and aged barium chloride solutions were mixed with sodium sulfate solutions. The sodium sulfate solutions were 5 x 10^{-4} molar, adjusted to a pH of 1.0. The barium chloride solutions were 0.05 molar and a twenty percent excess was used. The precipitation rate was followed by turbidimetric measurements with a Beckman Model B spectrophotometer; per cent transmission was plotted as a function of time after mixing of the solutions. Typical

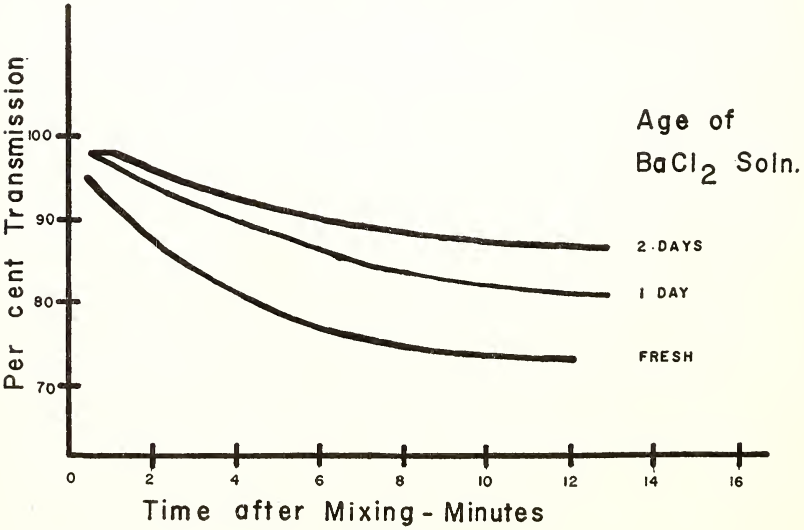


Figure 2.

curves are shown in figure 2. Each curve represents data obtained with a barium chloride solution of a certain age.

The final points of each curve indicate the relative particle sizes of the precipitates; the lower the per cent transmission, the smaller the particle size. The length of the growth period and the rate of growth appear to be constant. Assuming that nucleation occurs only during the induction period, and noting that the length of the induction period increases with the age of the barium chloride solution, we conclude that a fresh solution either nucleates at a faster rate than an aged solution or that there are initially excess nuclei in the fresh solution. It must be noted, however, that this experiment was conducted with extremely dilute solutions. With more concentrated solutions the nucleation period is so short that no measurements of its duration can be made by this method.

4. Effect of Adsorbents During the Aging Period

Adsorbents were kept in contact with barium chloride solutions during aging, and their effects on the particle size of barium sulfate were determined. Fresh solutions of 0.02 molar barium chloride were prepared containing glass wool, a porcelain crucible, or clay boiling chips. After known aging periods, portions of each solution were removed and added with shaking to a 0.016 molar sodium sulfate solution of pH 1.0. Particle sizes of the resulting precipitates were measured microscopically. Figure 3 is a plot of average particle size versus length of aging period. As indicated, the solutions containing added adsorbents produced larger particles for a comparable aging period than a control

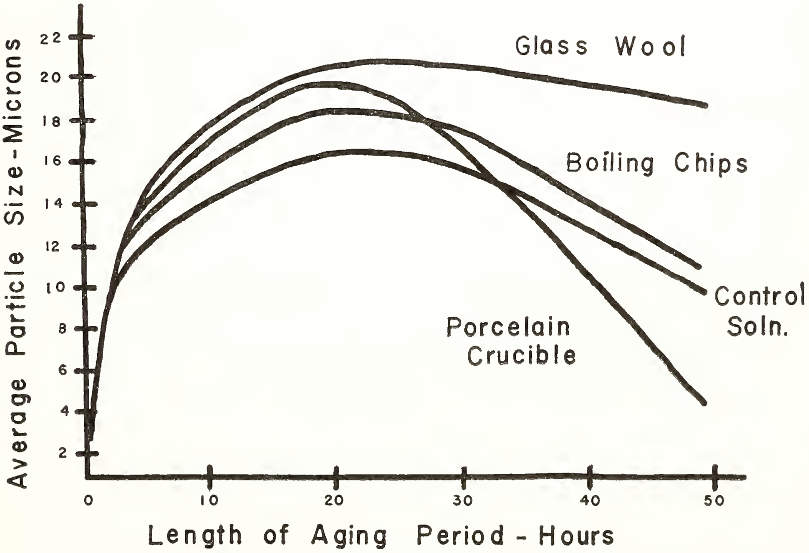


Figure 3.

solution. Glass wool, having the greatest surface area, produced the largest particles. The trend to smaller size again after long aging is shown by the maxima in all the curves.

5. Experiments With Radioactive Barium

In order to investigate Bogan's proposal that filtration removes undissolved barium chloride particles from a fresh solution by adsorption, radioactive barium was employed. Ba^{133} in the form of barium chloride was used as a tracer in filtration experiments with fresh and aged solutions. These experiments were performed both with Selas #3010 filtering crucibles and with Whatman #43 filter paper. Ten solutions of 0.02 molar barium chloride, partially active, were prepared for each filtering media. After known aging periods each solution was filtered through one of the media. The filtrates were evaporated, filter papers and crucibles dried, and the original beakers rinsed and dried. The activities of each were then counted with a Nuclear Instrument and Chemical Corporation Model 163 scaling unit. Ratios of activity of filter to activities of filter plus filtrate, and of activity on the walls of the beaker to total activity were calculated. The data are summarized in Table 1.

TABLE 1

Activity Ratios for Filtration Experiments with Barium Chloride Solutions

Sintered Porcelain Crucible

	Length of Aging Period before Filtration							
	0	30 min.	1 hr.	3 hrs.	7 hrs.	20 hrs.	45 hrs.	78 hrs.
Act. of filter / Act. of filter plus filtrate	.0825	.0825	.0806	.0872	.0880	.0790	.0843	.0770
Act. of beaker / Total activity	.0204	.0299	.0296	.0422	.0362	.0454	.0662	.0578

Filter Paper

	0	1 hr.	14 hrs.	42 hrs.	61 hrs.	110 hrs.	1 week
Act. of filter / Act. of filter plus filtrate	.260	.244	.231	.257	.239	.250	.243
Act. of beaker / Total activity	.0051	.0076	.0051	.0076	.0125	.0066	.0090

Statistics indicated no significant difference in the ratio of activity of filter to activities of filter plus filtrate for different aging periods. This was construed to indicate the absence of any detectable, undissolved barium chloride particles in a fresh solution, since if such were the case these ratios would be greater for a fresh solution than for an aged one. The increase in the ratio of activity on the walls of the beaker to total activity, with aging, particularly in the experiments with sintered porcelain crucibles, indicates an increased adsorption of barium ions on the walls of the container.

6. Other Solution Aging Effects

Investigation of the aging phenomenon was carried out with other solutions and precipitates. Slight, but real increases in particle size with age of the solution were noted for the following: (1) barium chloride in the precipitation of barium carbonate, (2) strontium chloride in the precipitation of strontium sulfate and strontium carbonate, and (3) barium nitrate in the precipitation of barium sulfate. No aging effects were found for: (1) barium chloride in the precipitation of barium chromate, (2) lead chloride in the precipitation of lead sulfate, and (3) calcium chloride in the precipitation of calcium carbonate. None of the effects were as pronounced as with aged solutions of barium chloride in the precipitation of barium sulfate.

Conclusion

Filtration of barium chloride solutions before aging appears to accelerate the complete cycle of the aging process.

With mixed solutions of fresh and aged barium chloride small barium sulfate particles are always produced, which seems to indicate the presence of excess nuclei in a fresh solution.

A fresh barium chloride solution may nucleate at a faster rate than an aged one, or the increased induction period on aging may also be due to the absence of excess nuclei initially present in a fresh solution.

Adsorbents kept in contact with barium chloride solutions during aging result in larger particles of barium sulfate than those produced from solutions aged without adsorbents.

Experiments with radioactive barium indicate the absence of any detectable, undissolved barium chloride particles in a fresh solution which could act as excess nuclei.

Although some other solutions exhibit aging effects, none are as pronounced as with barium chloride in the precipitation of barium sulfate. There appears to be no correlation between solutions which exhibit these effects.

It has been repeatedly shown that the particle size of barium sulfate is influenced by the age of the barium chloride reagent solution. The age of the sulfate reagent solution is of no effect. Since particle size depends on the number of nuclei available for particle formation, there must be more of these nuclei in a precipitate formed from a fresh solution than from an aged one. It is not clear what portion of the nuclei developed spontaneously during precipitation, and what portion must be present in the reagent solution. It is further not clear what any foreign nuclei in the barium chloride solution consist of, but it appears that they are not undissolved barium chloride particles. Probably nuclei coming from other sources, such as the walls of the container, play an important role. Experiments with other solutions which exhibit this phenomenon would be of value. The use of other techniques, such as polarography, which are not feasible with barium chloride solutions should yield important information.

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ENTOMOLOGY

Chairman: Howard O. Deay, Purdue University

John Favinger, State Department of Conservation, was elected chairman for 1958

ABSTRACTS

Electric Light Traps and Their Uses in Entomology. Howard O. Deay, Purdue University.—An electric insect trap consists of a collecting or killing device in which some kind of electromagnetic radiation is used as a lure. Although the response of insects to different wavelengths of radiant energy seems to be specific, most positively phototactic insects appear to be attracted more to lamps which emit their energy in the near ultraviolet region (2900-3900A) of the electromagnetic spectrum than to those which radiate either longer or shorter wavelengths. Light traps have been used by entomologists to make general collections of night flying insects, to determine time of appearance, abundance and distribution of certain injurious insects, to predict insect outbreaks, to time application of control measures, and to control certain insects.

The Role of Entomology in Science Fair Projects. J. J. Davis, Purdue University.—The science fairs which are available to high school students offer an increasing opportunity to promote the biological sciences in our high schools. Biology and vocational teachers have an excellent opportunity to promote such activities. A report is presented on Entomology projects for high school students as given in Turtox News for August, 1957.[1]

Notes on Artificially Induced Nesting of the Alkali Bee, *Nomia melanderi* Ckll. Earle A. Cross, Purdue University.—This paper summarizes a portion of the work carried on at the U. S. Legume Seed Research Laboratory, Logan, Utah, during the field seasons 1949-56, under the supervision of Dr. G. E. Bohart. The alkali bee, *Nomia melanderi* Ckll., is the most important pollinator of alfalfa in the Great Basin area. It nests gregariously, often in large numbers, in clayey or sandy alkali soils. Alfalfa seed growers fortunate enough to have nesting sites of these bees near their fields usually obtain excellent seed yields. Various methods of establishing the bees on acreages not previously populated by them were attempted as follows: 1.) Releasing adult bees at favorable locations. 2.) Caging adult bees on favorable sites. 3.) Transplanting soil blocks containing the prepupae of the bee. 4.) Burying prepupae in wooden or plaster-of-paris blocks in favorable locations. 5.) Preparing sites by clearing and irrigation.

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[1] Reprints of this article available from author.

Methods 1 and 2 were generally unsuccessful, methods 3 and 4 showed varying but small measures of success, and in areas where the bee is already established, the last method shows great promise as a method of inducing bees to populate new sites.

Prey Records of Ground Beetles (Coleoptera-Carabidae). RAY T. EVERLY, Purdue University.—The large numbers of species and the diversified habitats in which ground beetles occur makes this family one of the most important groups of predators in the control of many economic species of insects. Among the approximately 2500 species found in North America north of Mexico, only two are definitely known to be injurious to field crops. Several European species are reported as damaging strawberries. A few species are known to feed predominantly on pollen and weed seeds. Food records of over 90 species and varieties of ground beetles are given with literature citations supporting these records.

The Japanese Beetle Infestation in Newton County. GEORGE E. GOULD. Purdue University.—The Japanese beetle, *Popillia japonica* Newman, had infested several thousand acres along the Illinois-Indiana state line when its presence near Sheldon, Illinois, was first reported in 1953. This infested area had spread by 1957 to include some 60,000 acres in the two state area. The rapidity of spread and the change in larval food preference from the roots of grasses to those of corn and soybeans has caused concern to agricultural officials. As a consequence, investigations were started in Newton County to determine the biology of the insect and the amount of damage from both the adult and larval stages to agricultural crops. Observations during the past two years indicated that the first emergence of the beetle was in late June and the peak of adult abundance in late July. Beetles showed a decided preference for the foliage of smartweed throughout the summer and only small numbers were found on soybean foliage, corn silks and blossoms of clover. Some feeding was also observed on evening primrose, buttonweed, wild grape, willow, wild cherry and Virginia creeper. The only heavily infested soybean field had populations of 20 to 40 beetles per 100 feet of row, but damage to foliage was not of economic importance. Eggs of the new generation were found in early August and by the 15th grubs and eggs were common in the soil under corn and soybeans. In the field with heavy beetle population, counts of grubs and eggs were as high as 40 per corn hill or per foot of soybean row in late August, but by mid-September had dropped to 5 to 10. Both corn and soybeans in this field produced excellent yields.

Notes on the Distribution of the Japanese Beetle in Indiana. FRANCIS L. MADINGER, Indiana Department of Conservation.—Since discovery of Japanese beetle, *Popilia japonica*, in Indiana in 1934, annual, state-wide surveys have been conducted by the State Entomologist's office in cooperation with the United States Department of Agriculture to determine the distribution of this beetle within the state. These surveys have been, and are now, a most necessary adjunct to the control of this economically important plant pest.

Present known distribution of P. *japonica* in Indiana is limited to the northern half of the state. viz: Terre Haute, Indianapolis, Richmond, Kentland, Remington, Logansport, Fort Wayne, Kendallville, Garret, Elkhart, South Bend, Mishawaka, Plymouth, Argos, Wanatah, Gary, East Chicago, and Hammond.

The current, survey of southern Indiana, ie.: south of U. S. Highway No. 40, failed to discover Japanese beetle, however.

Detection of the beetle in the above listed areas was effected by using traps charged with a volatile bait, (direct) field scouting, and through the submission of specimens by interested persons or agencies.

Smartweed—*Polygonum* sp.—was the host found most preferred by feeding, adult beetles. The characteristic feeding injury, on this and other host plants, was invariably employed as a clue in detecting the presence of P. *japonica* in a given location when visual scouting was used.

While this pest was found on soybeans and corn, the survey did not reveal a significant loss in yield to a commercially important crop.

Occurrence of *Culiseta melanura* (Coquillet) in Indiana. R. E. SIVERLY, Ball State Teachers College.—Larvae of the mosquito, *Culiseta melanura*, were recovered from a bog area near Gaston, Indiana, on October 5, 1957. So far as it is known, this is the first record for *C. melanura* in Indiana. The virus of eastern equine encephalitis has been isolated from this species in other areas. Its occurrence in Indiana is noteworthy. This mosquito is probably more widespread in Indiana than is presently realized.

Drosophilidae Found in Tomato Fields in Indiana[1]

CARL A. SMITH, JR., Minneapolis, Minnesota

During the past several years importance of Drosophilidae with respect to contamination of tomato products has received increased attention. Several species of this family are readily attracted to tomatoes which serve as excellent oviposition sites. The problem is of particular importance since contamination can take place in the field where large populations of Drosophilidae deposit eggs in and on cracked tomatoes as well as at the cannery. Rather large populations can build up in a relatively short time due to the high biotic potential of some species.

The first step in attacking the problem of Drosophilidae in tomatoes is to determine the abundance of species of Drosophilidae attracted to the tomatoes. Little work has been done along this line, as most investigations have been concerned with control measures. Studies were carried out in three commercial tomato fields located near Klondike, Tippecanoe County, Indiana, during the late summer and early fall of 1956, to determine the species of Drosophilidae laying eggs on or in tomatoes, the species present in tomato fields, and the sex ratio of the adults.

Three types of traps were used at the start of these studies: glass jar, paper cup, and lard can. The glass jar type trap was made by soldering a metal cone in a Kerr ring and inserting it in a quart glass fruit jar. The paper cup trap was prepared by baiting a 12-ounce waxed cup and suspending it two feet above the ground. The cup was tilted at a 45° angle.

The most productive trap was the lard can type. Fifty pound lard cans were used with enough bait to cover the bottom completely. The lid was then placed on two small, inch-wide sticks, so that there was a narrow opening around the rim of the can through which the flies could enter. Since this trap collected many more flies than either of the other types, it was the only one used after the first week.

Two lard can traps were set in each field, one baited with tomato and the other with a banana-yeast mixture. The banana-yeast bait was made by mashing fresh bananas to a smooth pulp. A small amount of fresh yeast solution was added and the mixture allowed to stand for twenty-four hours to increase its attractiveness to the flies.

Flies were removed from these traps by a twelve inch insect net. When the lid was removed, the net was quickly placed over the top of the can. The tip of the net was held up and thus permitted the flies to enter the net. The flies were then killed in a wide mouthed killing jar charged with sodium cyanide and placed in vials to be counted at

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[1] This paper is based on a Master's thesis submitted at Purdue University in June, 1957. Research under the direction of Dr. H. O. Deay.

Contribution from the Agricultural Experiment Station, Purdue University, Journal Paper No. 1186.

a later time. The traps were checked, weather permitting, six days a week at approximately eight A. M. from August 30 until the end of the canning season, October 10. After that they were examined less frequently.

Trapping with the six traps in the three tomato fields produced a total of 6752 flies representing 13 species in the genera *Drosophila* and *Scaptomyza* (Table 1).

TABLE 1

Comparison of total numbers and species of Drosophilidae captured in traps containing tomato and banana-yeast baits in three tomato fields during September and October. Klondike, Indiana, 1956.

	Field A		Field B		Field C			Proportion of Total Catch
Species	T	B-Y[1]	T	B-Y[1]	T	B-Y[1]	Total	
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*Pct.*
Drosphila								
melanogaster	105	334	617	2413	195	502	4166	61.7
hydei	85	58	395	454	136	103	1231	18.2
busckii	53	14	401	223	80	34	805	11.9
affinis M[2]	3	8	43	121	9	15	199	2.9
tripunctata	0	0	37	28	2	0	67	.99
algonquin M[2]	1	1	7	42	4	11	66	.98
affinis & *algonquin* F[2]	0	2	10	23	0	3	38	.6
putrida	4	6	11	35	3	6	65	.97
quinaria			5	30	1	0	36	.52
immigrans			8	23			31	.46
robusta			2	1	0	1	4	.06
melanica			1	1	0	1	3	.04
Scaptomyza								
graminum	0	2	10	6	14	3	35	.5
adusta			2	3	0	1	6	.08
Total	251	425	1549	3403	444	680	6752	100.00

[1] T—Trap baited with tomato ; B-Y—Trap baited with banana-yeast

[2] M—Males ; F—Female flies

D. melanogaster Meigen was the most abundant of the species taken and comprised 61.7 per cent of the total number captured. *D. hydei* Sturtevant was the second most numerous species with 18.2 per cent and *D. busckii* Coquillet third with 11.9 per cent. Individuals of these three species represented 91.8 per cent of all the flies collected. Male flies outnumbered the females in all three fields and at each individual trap. Of the total individuals collected, 58 per cent were males to 42 per cent females.

The banana-yeast bait proved significantly more attractive to Drosophilidae than did tomato, as it attracted 66.8 per cent of all the flies taken. It was also significantly more attractive to the following species: *D. melanogaster*, *D. putrida* Sturtevant, *D. tripunctata* Loew, *D. affinis* Sturtevant, and *D. algonquin* Sturtevant and Dobzhansky. No significant differences were obtained for *D. hydei* and *D. busckii*. The remaining six species were too few in number for the results to be conclusive.

The total number of flies taken from each field differed. The three fields were planted with Kokomo variety tomatoes and varied with respect to the amount of foliage and plant growth, culled and crushed fruits present, and the nearness of possible sources of infestation.

There were some differences throughout the collecting period in the populations of the different species, as the abundance of most species fell into one of three categories. Group 1 includes those species which were abundant in catches throughout the collecting period; Group 2 those which were reasonably abundant when trapping commenced, but declined in numbers until they were completely absent from the daily catches; and Group 3 included the species rarely taken in early collections but more abundant in the late collections.

In Group 1 are placed the following species: *D. melanogaster*, *D. hydei*, and *D. busckii*. *D. melanogaster* was taken in large numbers at the onset but declined somewhat as the season progressed. The condition of the fruit in the field was primarily responsible for this decrease in numbers rather than the decrease in temperature.

The species included in Group 2 are *D. affinis*, *D. algonquin* and *D. putrida*. In Group 3 are *D. immigrans* Sturtevant, *D. quinaria* Loew, and *D. tripunctata*. The remaining species were taken in too few numbers to be classed in any group.

For rearing out adults in the laboratory the following types of tomatoes were selected at random: green; cracked and ripe on the vine; cracked and ripe on the ground; and those in traps infested with eggs and/or larvae. The rearing chambers used were pint ice cream cartons in which a hole had been punched in the side with a cork borer so that a glass vial could be inserted. After the adults had entered the vial, it was removed from the rearing chamber. The flies were chloroformed, identified to species, and counted.

Of the 136 tomatoes collected, 57 were infested (Table 2) and produced 4936 adults belonging to three genera and 10 species. *D. melanogaster* was reared in the greatest numbers making up 58.6 per cent of the total. *D. hydei* was second in abundance and *D. busckii* third. These three species constituted 98.6 per cent of all adults reared. *Chymomyza amoena* Loew was the only species of Drosophilidae reared from tomato, which was not taken in any of the traps. One, however, was sighted in a field but was not taken. The number of females was larger than males by a ratio of 58 to 42.

Of the cracked tomatoes in the fields, those on the vine were the least subject to egg deposition by Drosophilidae. The population increase was in cull and crushed fruit on the ground, fruits damaged in the picking operations, or damaged by the tomato fruit worm. No flies were reared from any green tomatoes, although eggs were present on some of them when taken into the laboratory. A close similarity between trapped and reared can be observed by comparing the number of *D. melanogaster*, *D. hydei*, and *D. busckii* trapped (Table 1) with the numbers reared (Table 2).

TABLE 2

Number of male and female flies of the family Drosophilidae reared from 57 ripe tomatoes, August 30 to October 12, 1956.

Species	Tomatoes in traps		Cracked from ground		Tomatoes from vine		Total		Grand Total
	M	F	M	F	M	F	Male	Female	
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Drosophila									
melanogaster	754	1006	389	536	86	122	1229	1664	2893
hydei	315	447	383	491	0	0	698	938	1636
busckii	23	33	90	146	11	39	124	218	342
immigrans	9	20	8	2	3	2	11	28	39
affinis	1	0	3	0	0	0	7	2	9
quinaria	0	0	1	1	0	0	1	1	2
tripunctata	0	0	1	0	0	0	1	0	1
Chymomyza									
amoena	0	0	1	0	0	0	1	0	1
Scaptomyza									
adusta	1	2	6	3	0	0	7	5	12
graminum	1	1	1	0	0	0	2	1	3
Total	1104	1509	883	1179	100	163	2807	2851	4938

Brief Descriptions of Drosophilidae Associated With Field Tomatoes in Indiana

Drosophila affinis Sturtevant

Body length 2.0 mm. Thorax blackish-brown with six rows of acrostichal hairs. Abdomen dark brown, lighter toward the base. Wings clear. Male sex-comb with four to six curved, black bristles. Females practically indistinguishable from those of *D. algonquin*. Eggs with two filaments which have expanded distal ends.

algonquin Sturtevant and Dobzhansky

Body length about 2.0 mm. Thorax blackish-brown with six rows of acrostichal hairs. Abdomen dark brown, lighter toward the base. Wings clear. Male sex-comb with eight to ten stout, curved black bristles. Females extremely difficult to separate from those of *D. affinis*. Eggs with two filaments.

busckii Coquillet

Body length about 2.0 mm. Thorax reddish-yellow with three longitudinal black stripes, one in each dorsocentral line and a median one which is bifed posteriorly. Acrostichal hairs in eight rows. Abdomen yellow, each segment with a black band that is interrupted in the mid-dorsal line and between that line and each lateral margin. Male with no sex-combs. Eggs with four rather slender filaments.

hydei Sturtevant

Boly length males about 3.0 mm. and females 3.4 mm. Thorax grayish brown, each bristle and hair arising from a dark brown spot. Acrostichal hairs in eight rows. Abdomen yellow, each segment with a black band that is interrupted in the mid-dorsal line. Wings clear. Male with no sex-combs. Eggs with four long tapering filaments.

immigrans Sturtevant

Body length about 2.5 mm. Thorax is brownish-yellow with eight rows of acrostichal hairs. A row of very short stout bristles on the lower apical part of each front femur is characteristic of this species. Abdomen yellow, each segment with an interrupted black band, the band on the fourth sometimes entire. Fifth segment black. Wings clouded at the tips of the first and second veins and on posterior cross vein. Male has no sex-combs. Eggs with four short tapering filaments.

melanica paramelanica Patternson

Body length approximately 2.5 mm. Thorax brownish-black, a darker longitudinal stripe in the median region. Acrostichal hairs are in six rows. Abdomen pale yellow with a medianly interrupted apical brown band on each segment. Wings clear. Males with no sex-combs. Eggs with four long tapering filaments.

melanogaster Meigen

Body length about 2.0 mm. Thorax reddish-yellow and the acrostichal hairs in eight rows. Abdomen black, the males with a reddish-yellow band on the basal half of the first three segments, and the females with the band on the first five abdominal segments. Wings clear. Male sex-comb with about ten stout black bristles. Eggs with two filaments, each with apical half expanded.

putrida Sturtevant

Body length about 2.0 mm. Thorax brownish-yellow, the acrostichal bristles in six rows. A pair of presutural bristles located in the acrostichal rows next to the outer ones. These bristles are often small but definitely larger than the surrounding hairs. Abdomen pale yellow, each segment with a medially interrupted brown band on the posterior margin. Wings clear. Eggs have four curved tapering filaments.

quinaria Loew

Body length about 2.5 mm. The thorax is yellow with six rows of acrostichal hairs. The abdomen is yellow, each segment with four posterior black spots. The wings clouded at tips of second, third, and fourth veins as well as both cross veins. Males with no sex-combs. Eggs with three filaments.

robusta Sturtevant

Body length about 2.5 mm. Thorax dark dull-brown with four faint pollinose longitudinal stripes. Acrostichal hairs in either six or eight rows. Abdomen grayish brown, each segment with an interrupted dark brown band. Wings clear, the posterior crossvein slightly clouded. Males with no sex-combs. Eggs with four tapering filaments.

tripunctata Loew

Body length about 2.5 mm. Thorax yellowish-brown with the acrostichal hairs in six rows. Abdomen is shining yellow with an interrupted dark-brown band on the posterior margin of each of the first three segments which is characteristic of this species. Wings clouded on both cross veins and at tips of second and third veins. No sex-combs on male. Eggs with four tapering filaments.

Scaptomyza adjusta Loew

Body length about 2.0 mm. The body color variable, from pale yellow to nearly black. Wings clear with a dark spot at the tip of the third vein. Thorax with four rows of acrostichal hairs. Eggs with four rather short pointed filaments.

graminum Fallen

Body length about 2.0 mm. Thorax dark brownish with two acrostichal rows of hairs. Abdomen dark brownish. Wings clear. Males with no sex-combs. Eggs with two short thick filaments.

Chymomyza amoena Loew

Body length about 2.0 mm. Thorax yellow with eight rows of acrostichal hairs. Abdomen dark brownish. Wings with three dark areas, one at apex of first vein, one across middle and posterior crossvein, and one below apex of second vein; tip of wings white. Males without sex-combs. Eggs with eight filaments.

Conclusions

1. Of the eight genera and 31 species of Drosophilidae recorded from Indiana, only three genera and 14 species were found to be associated with tomatoes in this study. Of these *D. melanogaster* was the most abundant, comprising 64.9 per cent of all species trapped and 58.6 per cent of the adults reared from tomatoes.
2. Among the flies trapped, the males outnumbered the females, 58 to 42 per cent. However, in the flies reared the females outnumbered the males by the same percentages.
3. The banana-yeast bait was found to be significantly more attractive to Drosophilidae than the tomato bait. It attracted 66.8 per cent of all flies trapped.
4. Drosophilidae collected in this study could be placed into three groups: (1) those taken in sizable numbers throughout the season; (2) those abundant at the start of the season but scarce toward the

end; and (3) those rare in early collections but increasing in abundance as the season progressed.

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Some New Insect Pests of Trees and Shrubs in Indiana[1]

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A number of insect pests of trees and shrubs new to Indiana have been discovered during the past several years. Several of these insects portend serious economic problems for the nurserymen, Christmas tree growers and home owners. These new pests are the Zimmerman pine moth, mimosa webworm, honey locust borer, Fullers rose beetle, spruce bud scale, tea scale, hypericum mealybug and holly leaf miner. The purpose of this paper is to bring these pests to the attention of the public and to publicize their presence in the state.

The Zimmerman pine moth, *Dioryctria zimmermani* (Grote) (fig. 1), was discovered infesting red and scotch pines in LaPorte County, Indiana in the fall of 1956 (U. S. D. A. determination). In the spring and summer of 1957 infestations ran as high as 25 percent in a commercial Christmas tree planting near LaPorte with an estimated loss of $20,000 to the growers.

The adult of the Zimmerman pine moth has a wing span of approximately one and a half inches. The body and fore wings are gray. The forewings have red markings and light and dark gray zigzag lines. The hind wings are tan to whitish with the color intensified along the margins. There is one generation per year.

Adult Zimmerman pine moths emerge during August and September with peak emergence occurring about August 14th. Being noctural they are observed only when disturbed. The eggs are deposited under bark flakes near wounds and pruning scars at the edge of resin masses. Under Indiana conditions most of the eggs hatch the following May and the young larvae tunnel in the newly developing leader or lateral growth. The larvae resemble a large European corn borer larvae and have a series of black dots on the body. The developing larvae girdle in the area of the first whorl of branches and when about mature may tunnel in the pith of the main stem for a distance of a foot or more. Full grown larvae are slightly less than an inch in length.

Illinois foresters report (9) that the insect can be controlled by applying two percent DDT in early August.

The mimosa webworm, *Homadaula albizziae* Clarke (fig. 2), which attacks mimosa and thornless honey locust in the southern half of the state, has been noticed since 1953 in the Indianapolis area. Determinations were made by the writer. Injury to honey locust is particularly noticeable in late August after attack by the second generation.

The moths are gray with a silvery sheen and the wings are lightly stippled with black spots. The adults, about ½ inch long, appear in June and lay eggs on the foliage. The larvae, dark brown diffused with pink, are about ½ inch long. They feed in colonies in the webbing spun

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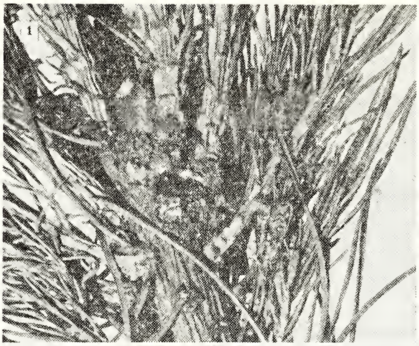
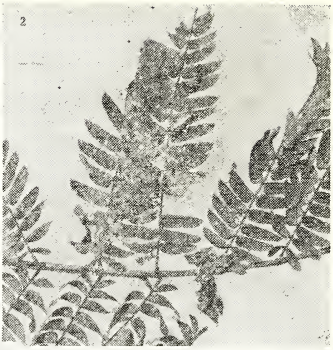
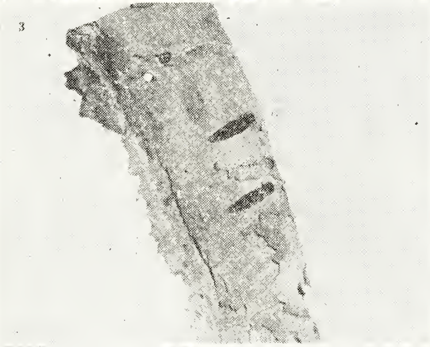
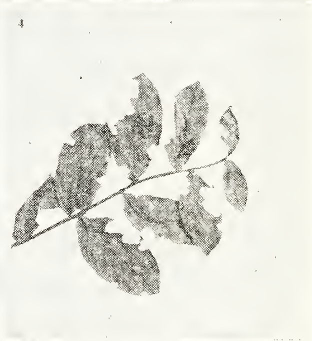
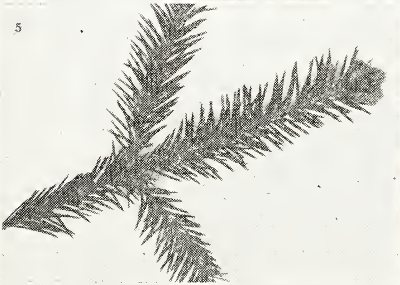
[1] Contribution from Purdue University, Agricultural Experiment Station, Journal Paper 1187.

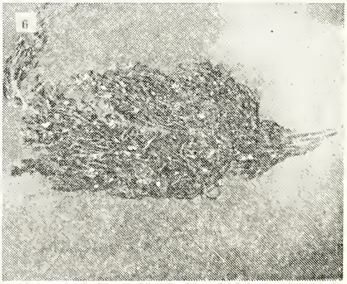


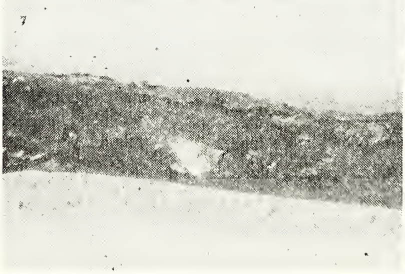












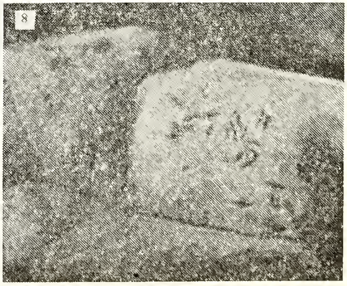


Figure 1. Zimmerman pine moth adult, larva and injury to whorl of Scotch pine, slightly reduced.

Figure 2. Mimosa webworm adult, larva pupa and injury to honey locust foliage, about one half normal size.

Figure 3. Honeylocust borer adults, larva and injury, about half normal size.

over the foliage where they skeletonize the underside of the leaflets. The injured leaves turn brown as if scorched by fire. In mid-summer the larvae pupate in the webs or drop to the soil or trunk where they spin flimsy cocoons in cracks and crevices of the bark or in the ground cover. Second generation adults emerge in early August.

Injury by the mimosa webworm can be prevented by spraying trees of susceptible species in mid-June and mid-August with either DDT or lead arsenate (11).

The honey locust borer, *Agrilis difficilis* Gory (fig. 3), was found attacking vigorously growing honey locust at Lafayette in 1956. Determinations were made by Dr. L. Chandler. The larval stage is a typical flat headed borer which burrows beneath the bark and eventually girdles the tree. One of the first symptoms of infestation is the exudation of large quantities of sap from infested areas. The adult beetles which emerge in June are about ½ inch long. The adult is elongated, black with a metallic lustre. There is one generation annually. No control measures are known at present (1, 4).

The fuller rose beetle, *Pantomorous godmani* (Crotch) (fig. 4), never before recorded from Indiana, was submited by County Agent E. T. Bond from Boonville for identification in late September, 1957. Determination was made by Dr. L. Chandler. This grayish-brown weevil was found eating ragged holes in the foliage of crape myrtle. The female weevils, which are wingless and reproduce parthenogenetically, lay from 10 to 60 eggs in late summer. The female places the eggs beneath bark flakes at the base of the stem. The eggs hatch in about a month and the larvae feed on the roots of the host plant (2, 11).

These weevils may be controlled by dusting with DDT, Lindane or Chlordane (11).

The holly leaf miner, *Phytomyza ilicis* (Curt.), was found damaging American holly in extreme southern part of Indiana in the summer of 1956 by the writer. The larval stage of this species produces serpentine mines in the leaves of holly which ruins their appearance since the infested leaves turn brown. The insect has one generation a year, and over-winters as a pupa in the leaf. Adults begin emerging in May and deposit eggs in slits in the leaf. The maggot mines in the leaves all summer and reaches maturity in the fall.

The holly leaf miner injury can be prevented by applying DDT or dieldrin when the adults start to emerge. The spray should be repeated in ten days. Young larvae in the leaves may be controlled by applying lindane or dieldrin in July (10, 11).

The spruce bud scale, *Physokermes piceae* (Schr.) (fig. 5), attacks spruce throughout the state but has never been listed as present in

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Figure 4. Fullers rose beetle and injury to crepe myrtle, about halr normal size.

Figure 5. Spruce bud scales at the node of a spruce branch, about half nor-normal size.

Figure 6. Juniper mealybugs on a juniper twig, about half normal size.

Figure 7. A colony of hypericum mealybugs on twig of St. John's wort, about normal size, Note crawlers.

Figure 8. Tea scales on a holly leaf, about normal size. Black scales are females and white scales the males.

Indiana until identified by the writer. The mature scales are about ⅛ inch in diameter, round and dark brown in color. They usually occur in clusters of 3 to 5 at the nodes and so closely resemble spruce buds that they are difficult to detect. The insect secretes large quantities of honeydew which attracts bees and acts as a substratum for growth of sooty black mold. There is one generation each year. The crawlers hatch in June and winter as partially grown scales.

The spruce bud scale can be controlled by applying dormant oil sprays during the winter or by spraying the crawlers in June with malathion or nicotine sulphate (3).

The juniper mealybug, *Spilococcus juniperi* Ehrborn (fig. 6), was collected from junipers at South Bend by P. T. Ulman in August 1954 and identified by the writer. The adult female is broadly oval, 1.5 - 2 mm. in length; dark red in color and the body is covered with a coarse, whitish powdery secretion, except for two narrow longitudinal stripes. The waxy filaments around the margin of the body are short, stubby and indistinct. The legs are very slender. The ovisac is small (6, 8).

The hypericum mealybuy, *Trachycoccus hyperici* Ferris (fig. 7), has been taken frequently on *Hypericum prolificum* (F) in a nursery at Lafayette by the writer and has been reported by Ferris, 1956, from Bloomington. The determination was made by Dr. G. F. Ferris. The adult female averages about 1.18 mm. in length and is an elongated oval in outline. In color the female is a dark reddish-purple dusted with a white powdery secretion. Reproduction is viviparous and there are two generations annually. The adult females overwinter and begin producing young in mid-May.

This mealybuy can be controlled by applying one of the phosphate insecticides in late May or early June while crawlers are being produced.

The tea scale, *Fiorinia theae* Green (fig. 8), was taken on *Ilex cornuta Burfordi* at Goshen by P. T. Ulman in 1955 and identified by the writer. The scale of the female is approximately oval, varying in length from 1-1.3 mm., with a width of about 0.5 mm. Color varies from a dark brown to almost black. There is a prominent central ridge and the posterior end is pointed. The males are about 1 mm. long and snow-white in color. Groups of male scales appear to be covered with white cottony threads. There are many over-lapping generations so that different stages can be present throughout the summer months (5, 8).

Applications of phosphate insecticides give effective control.

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Insects and Other Arthropods of Economic Importance in Indiana in 1957[1]

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The year 1957 in Indiana was characterized by conditions of high moisture and slightly lower temperatures, two conditions which combined to produce an abnormal insect season. Rainfall during the spring and early summer was between 3 and 4 inches above normal in most of the state, while early temperatures were 0.5° F. below normal average in the north and as much as 3° F. below in the southern area of Indiana during a similar period.

That the conditions which prevailed were unusual is evidenced by a brief abundance analysis of the 10 insects and other arthropods normally rated by our entomology staff as the most important on crops and trees in Indiana. They are corn earworm, potato leafhopper, European corn borer, cutworms, smaller European elm bark beetle, meadow spittle bug, two-spotted mite, codling moth, Hessian fly, and aphids. Of these, only the meadow spittle bug, probably the elm bark beetle, and possibly the potato leafhopper were of normal or highly economic importance. Not only were high moisture and less desirable temperatures direct factors, but many host crops had not yet reached a desirable state of growth at periods of normal insect abundance.

A detailed record of certain insects follows:

Field Crop Insects

Corn earworm (*Heliothis zea* (Boddie)). In 1956 the fall survey showed 50-85% of the ears infested in the state. There was no evidence of over-wintering as far north as Lafayette. In 1957, based on light trap records and field observation, the corn earworm was comparatively low (See tomato fruitworm), with counts ranging from 6.5% of the ears infested in the northern counties up to 43% in the southern most counties.

European corn borer (*Pyrausta nubilalis* (Hbn.)). The 1956 fall survey showed moderate counts in the northern ⅔ of the state both in percent infestation and number of borers per stalk. This spring egg laying was heavy in spots but survival was low. As a result, the first generation was never high, since most of the corn at time of oviposition was small due to weather incurred delays, and except in northern regions, the intensity of infestation decreased appreciably as the season advanced. Mid-summer moth flight was erratic and the fall larval generation was low except in the northern tier of counties which showed great variation between fields.

Armyworm (*Pseudaletia unipuncta* (Haw.)). The armyworm was neither abundant nor destructive in Indiana this year.

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Fall armyworm (*Laphygma frugiperda* (J. E. Smith)). Although states immediately to our west had extensive severe damage from this insect in southern counties, our damage was rather restricted to corn in Vanderburgh and Posey counties. In early August the larvae attacked corn leaves extensively and later entered the tips of the ears causing damage similar to that of the corn earworm.

Corn leaf aphid (*Rhopalosiphum maidis* (Fitch)) abundant only in scattered areas in corn and grain sorghum.

Northern corn rootworm (*Diabrotica longicornis* (Say)) occurred again as an adult pest of stalks and exposed tips of corn in southern Indiana.

Noctuid caterpillar (*Simyra henrici* (Grote)) recorded as feeding on the leaves of corn in appreciable numbers in Newton County.

Four-Spotted corn sap beetle (*Glischrochilus quadrisignatus* (Say)) generally abundant and pestiferous. Economically important in picked strawberries and raspberries readied for market.

Cutworms—General reduction noted over the populations which occurred last year.

Spittle bug (*Philaenus leucophthalmus* (L.)). This insect occurred in record abundance this season. High moisture and rank growth contributed to a population that reached counts of 5 per stem on alfalfa and clover in May in southeastern areas of the state.

Potato leaf hopper (*Empoasca fabae* Harris). This insect started entering the state early in May from the southwest and had achieved wide distribution by the 2nd week in June. Populations were moderately high early in the year, dropped off appreciably in the middle of August, but rose again to economic numbers late in the same month.

Two-spotted spider mite (*Tetranychus telarius* (L.)) generally less important economically this season.

Spotted alfalfa aphid (*Therioaphis maculata* (Buckton)). The introduction of this insect into Indiana late in 1956 seemed to indicate that we would have a heavy infestation in 1957. However, this aphid did not appear until the latter part of August. The intensity has been low although the area infested extended to include Crawford, Harrison, Floyd, Switzerland, Ohio, Dearborn, Dubois, Orange, Washington, Jefferson, Clark, Lawrence and Jackson counties. Sullivan, Knox, Daviess, Martin, Gibson, Pike, Posey, Vanderburgh, Warrick, Spencer and Perry counties were again infested as in 1956.

Green clover worm (*Plathypena scabra* (F.)) found to be common on soybeans in west-central Indiana with extensive but not serious feeding.

Plant bugs (principally *Lygus lineolaris* (P.deB.), *Adelphocoris rapidus* (Say), *Adelphocoris lineolatus* (Goeze)). Populations were high especially in the south on alfalfa and other legumes.

Clover root borer (*Hylastinus obscurus* (Marsh.)) feed extensively but due to high available moisture, stands of clover were able to recover from any injury caused by this insect.

Lesser clover leaf weevil (*Hypera nigrirostris* (F.)) was as heavy as in 1956 with 80-90% of the stems infested.

Clover leaf weevil (*Hypera punctata* (F.)). Populations low this year.

Hessian fly (*Phytophaga destructor* (Say)). Infestations light throughout the state except in Gibson County where a moderate infestation occurred.

Bean leaf beetle (*Cerotoma trifurcata* (Forst.)). For a number of years this insect has shown an increasing ability to adapt to soybeans. This summer some fields in the south had up to 25% leaf defoliation and nearly that amount occurred in many northern fields.

Japanese beetle (*Popillia japonica* Newm.). For the first time the adults of this insect were abundant enough on crops (soybeans in Newton County) to require chemical control. Statewide recommendations for control were made available this year due to the increasingly wide distribution.

Grasshoppers. The fall survey indicated a very low grasshopper population with one or less than one grasshopper per square yard. *Melanoplus femur-rubrum* (De G.) appeared to be the dominate species.

Chinch bug (*Blissus leucopterus* (Say)). As was expected, this insect did not develop in appreciable numbers this year.

Tomato fruitworm (*Heliothus zea* (Boddie)) was only moderately destructive this year with larval populations well below those experienced in 1956.

Squash bug (*Anasa tristis* (De G.)) not reported serious this year.

Spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber). Adults common on beans, squash, melons, and cucumber—normal.

Mint looper (*Rachiplusia ou* (Guerin)) was severely abundant in mint areas of the northern part of the state. The first generation larvae, early in July, defoliated up to 50% of the leaves of peppermint and spearmint and was also found infesting carrots, corn, and soybeans. The second generation looper was also abundant and destructive in untreated mint fields.

Fruit Insects

Oriental fruit moth (*Grapholitha molesta* (Busck)) was reported as generally severe in sub-standard orchards.

Codling moth (*Carpocapsa pomonella* (L.)) infestations were moderate to low in most orchards this season.

The apple aphid (*Aphis pomi* De G.) were of considerable concern to apple growers in the northern part of the state.

Mite populations were the lowest in ten years with most activity from the European red mite (*Metatetranychus ulmi* (Koch)), although the two-spotted spider mite built up toward the end of the season.

Tobacco Insects

Tobacco hornworm (*Protoparce sexta* (Johan.)) was more abundant on tobacco than it has been for some time, some fields being 100% infested with one or more larvae per plant.

Tomato hornworm (*P. quinquemaculata* Haworth) was only 1/10 as abundant on tobacco as *Protoparce sexta* (Johan.).

Tobacco flea beetle (*Epitrix hirtipennis* (Melsh.)) moderately abundant as normal except in tobacco seed beds where it was economically important.

The green peach aphid (*Myzus persicae* (Sulz.)) sometimes called the tobacco aphid, was economically important for the first time in 5 years doing damage late in the season.

Tree and Shrub Insects

Oak galls of several species were recorded in unusual abundance especially on white oak early in the season.

Fuller rose beetle (*Pantomorus godmani* (Crotch)) reported for the first time in Indiana (Warrick County) in late September attacking crape myrtle and forsythia.

Catalpha sphinx (*Ceratomia catalpae* (Bdv.)) larvae caused unusually heavy defoliation of trees in northern Indiana.

Zimmerman pine moth (*Dioryctria zimmermani* (Grote)) was first reported in Indiana late in 1956, and became alarmingly abundant this spring, in LaPorte county in red and Scotch pines. Moths were in flight early in the fall.

Elm leaf beetle (*Galerucella xanthomelaena* (Schr.)) was again recorded as destructive almost inclusively to Chinese elms especially in central and southern Indiana, although a northward trend is indicated. American elms almost free of infestation.

Bagworms (*Thyridopteryx ephemeraeformis* (Haw.)) continue to be economically very important on shrubs and trees in Indiana. Although not quite as abundant as the record year of 1956, the condition was severe.

Red-headed pine sawfly (*Neodiprion lecontei* (Fitch)) abundant in Owen County in July.

Sycamore tussock moth (*Halisidota harrisii* Walsh) was unusually abundant in the Lafayette area causing considerable defoliation.

Fall webworm (*Hyphantria cunea* (Drury)) extremely heavy in northern Indiana on black walnut, hickory, wild black cherry and oak.

European pine shoot moth (*Rhyacionia buoliana* (Schiff.)) destructive to buds of Scotch and red pine in LaPorte County in August.

Yellow-necked caterpillar (*Datana ministra* (Drury)) reported severe on multiflora rose and apple.

Locust leaf miner (*Chalepus dorsalis* Thunb.) damaged black locust very heavily throughout Indiana in August.

Mimosa webworm (*Homadaula albizziae* Clarke) was abundant on Moraine and Thornless honey locust in the Indianapolis area and south.

Man and Animal and Household Insects

German cockroach (*Blattella germanica* (L.)) is increasing in abundance rapidly due primarily to its widespread resistance to chlordane and change in habits.

Brown banded cockroach (*Supella supellectilium* (Serv.)) continues to be increasingly important in homes throughout the state.

Box-elder bug (*Leptocoris trivittatus* (Say)) continued to be important in the fall of the year principally because convenient control measures are unavailable.

Subterranean termite (*Reticulitermes flavipes* (Kollar)) is apparently increasing in importance due principally to desirable environments provided by new types of house construction.

House fly (*Musca domestica* L.) was unexpectedly low this season in spite of favorable moisture conditions.

Dog and cat fleas (*Ctenocephalides canis* (Curt.) and *C. felis* (Bouché)) have become major problems due to the increasing amount of DDT resistance.

American dog tick (*Dermacentor variabilis* (Say)) reached its highest population in many years, being unusually abundant in wooded areas throughout the spring.

Mosquitoes of most common species were unusually abundant throughout the year due to the continuous supply of standing water.

The year 1957 in Indiana was rather unusual from the standpoint of economically important insects. Populations of principal species were generally lower than normal while several species of other insects became unusually abundant.

Location of Larvae of the European Corn Borer, Pyrausta nubilalis (Hbn.), in Dent Corn[1]

CLAYTON A. MULLIN, Burrows, Indiana

A study was made during the summer of 1956 in two corn fields located in Carroll County, Indiana, to determine the location throughout the season of both first and second generation larvae of the European corn borer in dent corn. Field I was planted May 16 and was infested mainly with first generation borers. Field II was planted June 4 and was infested with second generation larvae.

The literature on the European corn borer is voluminous but it is practically devoid of references regarding the location of the insect in the plant. A paper by Huber, Neiswander and Salter of Ohio (1) dealing with the location of the single generation corn borer larvae and one by Patch, Deay and Snelling of Indiana (2) in the location of the August generation of the two brooded corn borer larvae, were the only references to the subject.

Field I. Procedure. Field I consisted of twenty-two acres of dent corn. This field was a two year alfalfa sod, top-dressed with nine tons of barnyard manure and 400 pounds per acre of commercial 0-24-24 fertilizer. An additional one hundred pounds of 0-20-20 was placed in the row at planting time. The usual methods of plowing and preparing the seed bed were followed. Three varieties of hybrids were used: Pioneer, Steckleys, and Carghill.

On July 7, 1956 this field was sprayed with 2,4-D Amine at the rate of one pint per acre. No insecticides were used.

All studies made in this field were on first generation corn borer. The first oviposition was observed on June 10, with the peak of oviposition from June 12 to 16. The first larvae were found June 19.

Examinations and tabulations were made daily, with few exceptions, until July 23, after which the data were recorded on alternate days. Beginning September 19, examinations were made every third day until October 24, at which time the corn was husked.

Each observation consisted of ten infested plants which were uprooted and dissected completely, starting with the lowest node and leaves and working to the top of the plant. From each stalk dissected, record was made of the number and location of all egg masses, larval instars, and pupae. The height of the corn was measured from the ground level to the tip of the extended leaves and recorded. The stage of development of the plant was recorded according to the following classification: whorl, tassel, shooting, silking, milk, dent and mature.

Results. As shown in Table 1, 90 per cent of the first instar corn borers were found on the leaves, about 92 per cent of these being on

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[1] Purdue University Agricultural Experiment Station Journal Paper No. 1190. The data presented here was obtained in preparation of a Master's thesis at Purdue University. The work was under the direction of Professor H. O. Deay.

TABLE 1. Occurrence of first generation larvae of the European corn borer by instars in different parts of the corn plant in Field I. Carroll county, Indiana, 1956.

Instar	On leaf	In midrib	Behind sheath	Inside stalk	In ear	In shank	Total	Dates found
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*No.*	
1	90.3	0	9.1	0.6	0	0	171	June 19—July 10
2	73.2	12.1	13.5	1.2	0	0	545	June 19—July 21
3	61.2	20.8	11.7	6.3	0	0	205	June 21—July 21
4	36.4	32.1	13.7	17.8	0	0	136	June 28—Aug. 12
5	12.9	15.5	13.4	55.1	2.6	0.9	192	July 6—Aug. 22

leaves six through 10. About 10 per cent of all first instar larvae were concealed behind the sheath and less than one per cent were in the stalk.

Seventy-three per cent of all second instar corn borers were found exposed on the leaves, with about 90 per cent of these being on leaves six through 11. Nearly 14 per cent were behind the sheath and 13 per cent in the midrib or in the stalk.

Sixty-one per cent of the third instar borers were exposed on the leaves, about 75 per cent of which were on leaves eight through 13. About 12 per cent were behind the sheath. Twenty-seven per cent were not exposed, being either in the midrib or in the stalk.

Thirty-six per cent of the fourth instar corn borers were found exposed on the leaves, about 61 per cent of these being on leaves nine through 13. Nearly 50 per cent were either in the midrib or in the stalk and about 14 per cent were behind the sheath. Most of the larvae other than those on the leaves, were below the ear, which usually appeared at node nine.

Thirteen per cent of the fifth instar corn borers were exposed on the leaves. They were fairly evenly distributed from leaf four through 16. About 13 per cent were behind the sheath. The midrib contained 15.5 per cent, the stalk 55 per cent most of which were below the ear, with the latter containing 3 per cent, and the shank 0.5 per cent. Thus nearly 74 per cent of the borers were concealed.

Forty-seven per cent of the pupae were found on the leaves, being distributed from leaf four through 14. About 19 per cent of the pupae were found in the stalk, 6 in the ear and 28 per cent were found behind the sheath. Eighty-one per cent of the pupae were found below the ear.

Twenty-three per cent of the empty pupal cases were found on the leaves and 12 per cent behind the sheath. The remaining 65 per cent were found in the stalk, about 78 per cent of these were below the ear.

Forty-eight observations of ten plants each (480 plants) were made from June 19 to August 22 yielding 1249 larvae, 32 pupae and 48 empty pupal cases. Of the larvae found 171 or 13.7 per cent were first instar; 545 or 43.7 per cent were second instar; 205 or 16.3 per cent were third instar; 136 or 10.9 per cent were fourth instar; and 192 or 15.4 per cent were fifth instar.

There was a sharp decrease in the number of borers present after July 10.

Summary. In Field I, 90.3 per cent of the first instar borers, 73.2 per cent of the second, 61.2 per cent of the third, 36.4 per cent of the fourth and 12.9 per cent of the fifth instar were on the leaves.

Of the first instar larvae 9.1 per cent were behind the sheaths, 13.5 per cent of the second, 11.7 per cent of the third, 13.7 per cent of the fourth, and 13.4 per cent of the fifth. Thus 99.4 per cent of the first instar, 86.7 per cent of the second, 72.9 per cent of the third, 50.1 per cent of the fourth, and 26.3 per cent of the fifth could have been reached by insecticides.

The percentage of larvae found in the midribs was as follows: First instar none, second instar 12.1 per cent, third instar 20.8 per cent, fourth instar 32.1 per cent and fifth instar 15.5 per cent.

As the borers matured a higher percentage were found inside the stalks. Over half the borers were found at or below the ear.

Six-tenths of one per cent of the first instar borers were in the stalk, 1.2 per cent of the second, 6.3 per cent of the third, 17.8 per cent of the fourth, and 55.1 per cent of the fifth.

There were no first, second, third, nor fourth instar larvae found in the ear or shank and only 3.1 per cent of the fifth instar were found in this area. Also 6.2 per cent of all pupae were found in the ear.

The first instar larvae were present from June 19 to July 10, second instar from June 19 to July 21, third instar from June 21 to July 21, fourth instar from June 28 to August 12, fifth instar from July 6 on. Pupae were found from July 13 to August 22, and pupal cases from July 29 to October 20.

There were 1249 larvae found in 480 stalks dissected over a period of 48 days in Field I. Each stalk dissected was infested with an average of 3.6 borers. Of the total borers found 171 or 14 per cent were first instar, 545 or 42 per cent were second, 205 or 17 per cent were third, 136 or 11 per cent were fourth, and 192 or 16 per cent were fifth instar. There were 32 pupae and a like number of empty pupal cases.

Field II

Procedure. Field II consisted of 11 acres of dent corn. This field was a two year alfalfa sod and received 200 pounds of commercial 4-16-16 fertilizer per acre. Howett's (600 series) and Martin brothers' (400 series) seed corn were used. Each planter box contained a different variety. Having been planted June 4 this field was infested only with second generation borers.

Four acres in this field were selected at random and 160 plants containing egg masses were staked. Each egg mass on the plant was marked and the location tabulated on the data sheet. One plant was dissected every other day from each of the above four areas and one plant at random (not within the limits of the above four). Thus a total of five plants were dissected every other day, beginning August 3 and ending October 30.

No insecticides nor herbicides were used in this field.

The first egg mass and larvae were found August 3. The tassels appeared August 9. The average ear height was on node nine.

TABLE 2. Occurrence of second generation larvae of the European corn borer by instars in different parts of the corn plant in Field II. Carroll county, Indiana, 1956.

Instar	On leaf	In midrib	Behind sheath	Inside stalk	In ear	In shank	Total	Dates found
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*No.*	
1	64.6	0	31.6	0	3.8	0	79	Aug. 3—Sept. 25
2	28.6	3.9	41.5	1.6	21.3	3.1	132	Aug. 13—Sept. 16
3	19.2	5.6	40.3	5.6	24.5	4.8	124	Aug. 13—Sept. 20
4	14.3	1.6	27.2	18.7	25.5	12.7	118	Aug. 21—Sept. 22
5	2.9	0.2	7.1	67.4	13.6	8.8	614	Aug. 23 — Oct. 30

Results. As shown in Table 2 nearly 65 per cent of the first instar corn borers were on the leaves, about 57 per cent of which were on leaf ten. About 32 per cent of all first instar larvae were hidden behind the sheath. Three per cent were found in the ear and none in the stalk. About 91 per cent of the first instar larvae were in the ear or above.

Nearly 29 per cent of all second instar corn borers were found exposed on the leaves, with about 69 per cent of these being on leaves eight through 12. About 4 per cent of all second instar borers were in the midrib, 1.6 per cent in the stalk, 21.3 per cent in the ear and 3.1 per cent in the shank. About 41 per cent of all second instar larvae were behind the sheath. About 77 per cent of the second instar, second generation larvae were in or above the ear.

About 19 per cent of the third instar borers were exposed on the leaves. Leaves eight through 13 contained about 58 per cent of the above. About 40 per cent were behind the sheath. Nearly 41 per cent of all third instar borers were concealed, 5 per cent being in the midrib, 5 per cent in the stalk, 25 per cent in the ear and 5 per cent in the shank. Of the total third instar borers about 65 per cent were at or below the ear.

Fourteen per cent of the fourth instar corn borers were on the leaves, with 64 per cent of them on leaves nine through 13. About 27 per cent were behind the sheath. Of all four instar larvae 59 were inside the corn plant. These were located as follows: midrib 1.6, stalk 18.7, ear 25.5 and shank 12.7. About 83 per cent of the fourth instar larvae were in the ear or above it.

Less than three per cent of the fifth instar corn borers were on the leaves and were evenly distributed from leaf five through 15. Only 7.1 per cent were behind the sheath. Thus 90 per cent of the fifth instar larvae were inside the plant, with 0.2 per cent being in the midrib and 67.4 per cent in the stalk (all were found between node three and 16). Thus 62.5 per cent were above the ear with 13.6 per cent actually in the ear and 8.8 per cent in the shank. Of all fifth instar larvae 60.8 per cent were found at or above the ear.

One pupae was found October 6 inside the stalk at internode six. Two empty pupal cases were found on October 18 and 24, both inside the stalk and at internode seven.

There were 1067 larvae found in 205 stalks dissected over a period of 41 days in Field II. Each stalk dissected was infested with an average of 5.2 borers. Of the total borers found 79 or 7.4 per cent were first instar, 132 or 12.4 per cent were second, 124 or 11.6 were third, 118 or 11 per cent were fourth, and 614 or 57.6 per cent were fifth instar. One pupae was found October 6 and two empty pupal cases—one on October 16 and the other on October 24.

The number of borers present declined toward the last of September.

The variation in the number of larvae found in each instar is influenced by the period of time spent in each instar and the number of observations and the number of plants dissected during this period.

Summary. In Field II 64.6 per cent of the first instar larvae were located on the leaves, 28.6 per cent of the second, 19.2 per cent of the third, 14.3 per cent of the fourth, and 2.9 per cent of the fifth.

Thirty-two per cent of the first instar larvae were behind the leaf sheaths, 41.5 per cent of the second, 40.3 per cent of the third, 27.2 per cent of the fourth, and 7.1 per cent of the fifth. Thus over 95 per cent of the first instar were located on the leaves or behind the sheaths, 70.1 per cent of the second, 59.5 per cent of the third, 41.5 per cent of the fourth and ten per cent of the fifth.

No first instar larvae were found in the midrib. About four per cent of the second instar larvae were in the midrib, 5.6 per cent of the third, 1.6 per cent of the fourth, and 0.2 per cent of the fifth. In the stalk there were no first instar larvae, but 1.6 per cent of the second, 5.6 per cent of the third, 18.7 per cent of the fourth, and 67.4 per cent of the fifth instar larvae.

In the ear and shank there were 3.8 per cent of the first instar larvae, 24.4 per cent of the second, 29.3 per cent of the third, 38.2 per cent of the fourth, and 22.4 per cent of the fifth instar larvae.

The location of the larvae in relation to the ear was as follows: ninety per cent of the first instar larvae were in or above the ear, 76.6 per cent of the second, 64.6 per cent of the third, 83 per cent of the fourth, and 57.4 per cent of the fifth.

The first instar larvae. Of the second generation larvae found in Field II first instar larvae were present from August 3 to September 16, second instar August 13 to September 16, third August 13 to September 20, fourth instar August 21 to September 22, and fifth instar August 23 to October 30.

Literature Cited

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The Anthophilous Insects of Indiana

2. A Preliminary List of the Diptera[1] Collected from Blossoms[2]

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Several thousand specimens of anthophilous insects have been collected in Indiana since 1950 in the course of a study of the ecology of bumble bees, including their relationships to flowers of all types and to the other insects which also visit flowers. A list of the Apoidea of the state 11) based upon specimens obtained in this study and all other available records was published last year. The second most numerous group of flower-visiting insects is the Diptera and a list of the species of this order included in the collections is presented here.

Some of the species listed are probably not true anthophilous insects in the sense that they visit flowers for nectar and/or pollen, or, even, that they effect pollination. Their presence upon blossoms may be for the purpose of predation, or, possibly, merely fortuitous resting upon a prominent or convenient portion of a plant. However, such presence of itself may have a certain competitive effect upon true pollinating forms.

No other published records of anthophilous Diptera of the state are known to the author. A number of papers by Say (12), Coquillett (6, 7), Webster (14), Cook (2-5), Smith (13), Montgomery (10) and Hart (9), give records of the species of certain families or ecological groups (gall-makers, other plant borers and miners, lepidopterous parasites), etc., and the bibliography of Indiana Arthropoda assembled by the author under assignment from the Academy's Biological Survey Committee about 1932 includes 100 entries for the Diptera (furnished by the late C. F. Adams).

In 1954 numerous reports were received from beekeepers that "swarms of flies were robbing sweet clover of nectar and driving honey bees 'away'" from this plant. The species responsible for such reports appears to be *Archytas apicifer* (Walker), a tachinid parasite of lepidopterous larvae, especially armyworms and cutworms. The author has notes and specimens of such an occurrence which he observed in Morgan County in 1937. Records from specimens in the University Collections, chiefly obtained in these studies, show that this species has been taken rather frequently from the flowers of sweet clover and a number of other plants. However, a concentration of flies sufficient for observations and tests has been found only in September, 1956, when a considerable population was noted in a clump of *Eupatorium altissimum* L., on a R.R. right-of-way in northern Montgomery County.

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[1] Determinations of examples of all species and of most specimens, except of the more common species, have been made by specialists of the Insect Identification unit of the Entomology Research Division of the U. S. Department of Agriculture—P. H. Arnaud, W. L. Downes, Jr., R. H. Foote, C. W. Sabrosky, A. Stone, and W. W. Wirth. Valuable assistance in the determination of plants has been given by D. L. Schuder, A. T. Guard and George Cummins of the Departments of Entomology, Biology, and Botany and Plant Pathology, Purdue University.

[2] Purdue University Agricultural Experiment Station Journal Paper No. 1192.

It is recognized that many differences exist between the complex of pollinating insects found in fields or extensive stands of sweet clover and the clump of Eupatorium studied:

1. The number of species involved is much greater on Eupatorium,
2. The area of Eupatorium under observation was infinitely less than any area of sweet clover of value for honey production (the area of the "clump" studied was probably between 200 and 300 square feet),
3. The form of the flower head is much different, the flowers of Eupatorium forming a more or less continuous surface area, those of sweet clover being scattered.

However, the observations may be of some value on the general subject of competition among anthophilous insects, in addition to the specific conditions on fall-flowering composites which are of considerable value as a source of the fall "honey-flow."

A very few honey bees were noted, and the competition from other insects, chiefly *A. apicifer*, may have been responsible, as honey bees were observed working Eupatorium industriously at other locations at this time. Although about 60 species and varieties of Diptera and Hymenoptera (a few of each order as well as a few specimens of Coleoptera, Hemiptera, Orthoptera and Lepidoptera have not been determined) were taken on the two days, September 9 and 12, when collections were made, only two were present in any considerable numbers. The number of each species collected on each day is indicated in the following table:

HYMENOPTERA

Braconidae: *Cardiochiles viator* (Say) -1-10.

Eurytomidae: *Bruchophagus gibbus* (Boh.) -0-2.

Tiphiidae: *Myzium maculatum* (Fabr.) -1-5; *M. 5-cinctum* (Fabr.) -0-3.

Vespidae: *Polistes fuscatus fuscatus* Cress. -0-2; *P. f. pallipes* Lep. -1-1.

Pompilidae: *Priocnemioides fulvicornis* Cress. -0-2; *Paracyphononyx funereus* (Lep.) -0-1.

Sphecidae: *Tachytes aurulentus* (Fabr.) -1-4; *Larropsis distincta* Smith -1-0; *Chlorion pennsylvanicum* (Linn.) -1-0; *C. nudum* (Fern.) -1-0; *C. auripes* Fern. -1-0; *Sphex nigricans* (Dahl.) -0-1; *Stictia carolina* (Fabr.) -0-2; *Cerceris clypeata* Dahl. -0-1.

Apidae: *Xylocopa virginica* (Linn.) -0-1; *Bombus affinis* Cress. -1-0; *B. auricomus* (Robt.) -1-0; *B. fraternus* (F. Smith) -1-0; *B. griseocollis* (DeGeer) -2-3; *B. impatiens* Cress. -3-1; *Apis mellifera* Linn. -/-/.

DIPTERA

Bombyliidae: *Sparnophilius fulvus* (Wied.) -1-0.

Syrphidae: *Mesograpta marginata* (Say) -1-0; *Spilomyia longicornis* Loew -1-0; *Syritta pipiens* (Linn.) -0-1; *Tubifera arbustorum* (Linn.) -2-0.

Conopidae: *Physoconops brachyrhynchus* Macq. -2-0.

Tachinidae: *Alophorella aenoventris* (Will.) -3-0; *Archytas apicifer* (Walk.) -/-/; *Bonnetia comta* (Fall.) -1-0; *Cylindromyia fumipennis* (Big.) -0-1; *Enclytia flava* (Tns.) -0-1; *Gonia sequax* (Will.) -0-1; *Gymnoclytia occidua* (Walk.) -2-1; *Hyalomyodes triangulifera* (Loew) -2-0; *Leucostoma simplex* (Fall.) -1-0; *Myiophasia nigrifrons* (Tns.) -2-0; *M.* sp. -1-0; *Phorocera claripennis* Macq. -1-0; *Trichopoda pennipes* (Fabr.) -0-1.

Calliphoridae: *Callitroga macellaria* (Fabr.) -/-/; *Phaenicia sericata* (Mg.) -3-3; *Pollenia rudis* (Fabr.) -3-0.

Sarcophagidae: *Amobia erythrura* Wulp. -3-0; *Sarcophaga bullata* Pk. -0-1; *S. impar* Old. -1-1; *S. lherminieri* R.D. -6-1; *S. rapax* Walk. -0-3; *S. ventricosa* Wulp. -5-1; *Senotainia* sp. -1-0.

Muscidae: *Musca domestica* Linn. -1-0; *Othellia caesarion* (Mg.) -1-0; *Paregle cinerella* (Fall.) -0-1; *Stomxys calcitrans* (Linn.) -1-0.

Archytas apicifer and *Callitroga macellaria* were common, but *A. apicifer* was much more abundant. The actual populations were difficult to estimate but between 100 and 150 individuals of *A. apicifer* were collected for cage tests each day. After about 20 or 30 flies had been collected the population would appear to be exhausted, but within five to ten minutes it would be as great as before the collection. This appears to indicate a very dense and mobile population within the vicinity. Of course, an extensive area of bloom, such as a field of sweet clover, might show a different condition of population movement. The apparent heavy population, however, would seem to confirm the observations of beekeepers that sweet clover is sometimes invaded by swarms of flies. The flies were quite restless and continually darted from one flower to another; there was some indication that they tended to fly to flowers already occupied by another fly of this species, or by some other insect (by error?). It was not definitely determined if this action was a mating attempt; although two flies frequently left the flower together actual copulation was not observed. Such actions of other insects are very disturbing to honey bees, and the few bees observed were frequently driven from the individual flower heads, if not from the entire area by the darting flies. It is probable that this activity when sweet clover is visited by "swarms" of flies would drive away the bees even if the nectar supply is not exhausted by the feeding of the flies.

Several series of tests to determine the amounts of sugar syrup which might be consumed by these flies were attempted. Flies were observed to feed freely but the rapid evaporation from the solutions in check cages and the short life of the flies in cages (one-half to two-thirds died within 10-12 hours) rendered the tests unreliable.

The records in the following list follow the plan of the first paper of the series (11)—for each species known distribution within the state is listed by counties, seasonal distribution by earliest and latest dates of collection and the plants from which flies have been taken are listed by genera following the nomenclature and sequence of Deam (8). Nomenclature and sequence of the families of Diptera follow Borror and DeLong (1); genera and species are arranged alphabetically.

List of Species

8. CERATOPOGONIDAE

1. *Dasyhelea* sp. Tippecanoe. May 24. Gypsophila.

15. SCATOPSIDAE

2. *Ectaetis clavipes* (Loew). Tippecanoe. May 28. Paeonia.

17. SCIARIDAE

3. *Lycoria* sp. Tippecanoe. July 24. Curcurbita.
4. *Eugnoriste occidentalis* Coq. Tippecanoe. June 24-Sept. 1. Leonurus; Taraxacum-2.
5. *Bradysia* sp. Gibson, Tippecanoe. July 7-Sept. 8. Sedum-2; Melilotus; Daucus-1,1; Ipomoea.

20. STRATIOMYIIDAE

6. *Eulalia cincta* (Oliv.) Tippecanoe. July 7. Eryngium.
7. *Eulalia mugo* (Wied.). Tippecanoe. July 7. Eryngium.
8. *Eulalia pilimana* (Lw.). Tippecanoe. July 7. Daucus; Asclepias.
9. *Eulalia* sp. Tippecanoe. July 19. Pastinaca-2.
10. *Nemotelus* sp. White. Aug. 9. Eryngium.
11. *Stratiomys discalis* Loew. Tippecanoe. June 3-8. Euonymus-1,2.
12. *Stratiomys norma* Wied. Tippecanoe. June 16. Euonymus.
13. *Stratiomys* spp. Tippecanoe. June 8-19. Euonymus; Pastinaca-3.

24. TABANIDAE

14. *Tabanus quinquevittatus* Wied. Jackson, White. July 23-Aug. 9. Trifolium-3; Eryngium.

26. SCENOPINIDAE

15. *Omphrale nubilipes* (Say). Spencer. Sept. 10. Ricinus.

27. NEMESTRINIDAE

16. *Neorhynchocephalus volaticus* (Will.) Allen. Aug. 6. Cirsium.

29. BOMBYLIIDAE

17. *Bombylius azaleae* Shannon. Tippecanoe. June 24. Agastache.
18. *Bombylius major* Linn. Tippecanoe. April 20-27. Claytonia; Taraxacum.
19. *Exprosopa fasciata* Macq. Tippecanoe, Warren, White. Aug. 2-11. Monarda-2; Mentha; Liatris; Cirsium-2.

20. *Sparnopilius fulvus* (Wied.) Jasper, Montgomery, Spencer, Tippecanoe. July 25-Sept. 16. Polygonum; Mentha-3; Eupatorium-5, 1,1; Solidago-1,3,1; Erigeron; Rudbeckia-2.
21. *Systoechus vulgaris* Lw. Marshall. Aug. 23. Medicago.
22. *Systoechus* sp. Marshall, Tippecanoe, Warren, White. July 27-Aug. 31. Medicago; Eryngium; Agastache-3; Liatris-2; Tagetes; Cirsium-2.
23. *Villa impiger* (Coq.). Marshall. Aug. 9. Euphorbia.
24. *Villa sinuosa* (Wied.). Tippecanoe. May 22. Paeonia.
25. *Villa* sp. Montgomery. Sept. 12. Solidago.

30. ASILIDAE

26. *Atomosia sayii* Johnson. Gibson. July 12. Cephalanthus.
27. *Diogmites neoternata* Brom. Tippecanoe. July 26-27. Agastache; Mentha.
28. *Leptogaster* sp. Tippecanoe. June 19. Trifolium.
29. *Proctacanthus* sp. Montgomery. Sept. 12. Eupatorium.

33. EMPIDIDAE

30. *Empis clausa* Coq. Tippecanoe. July 27-Aug. 16. Mentha-1,21; Citrullus.
31. *Empis* sp. Tippecanoe. Apr. 27. Salix.
32. *Hilara* sp. Tippecanoe. Apr. 27. Salix.

34. DOLICHOPODIDAE

33. *Condylostylus* sp. Tippecanoe. Sept. 5. Ricinus.

39. SYRPHIDAE

34. *Allograpta obliqua* (Say). Grant, Tippecanoe, Tipton. Apr. 27-June 19. Salix, Euonymus; Paeonia; Pastinaca-1,2; Taraxacum.
35. *Brachypalpus oarus* (Wlk.). Tippecanoe. April 5. Salix.
36. *Chrysogaster nitida* Wied. Grant, Tippecanoe, White. April 5-Aug. 9. Salix-1,2,1; Prunus; Eryngium; Pastinaca-2; Agastache.
37. *Helophilus fasciata* Walker. Gibson, Grant, Tippecanoe. April 1-27. Salix-8,4,3,1; Prunus; Stellaria-2,1.
38. *Helophilus latifrons* Lw. Tippecanoe. April 14. Salix.
39. *Melanostoma mellinum* (Linn). Tippecanoe. June 19. Pastinaca.
40. *Melanostoma* sp. Tippecanoe. April 5. Salix.
41. *Mesograpta geminata* (Say). Carroll, Tippecanoe. June 9-July 23. Melilotus-3; Agastache. Cephalanthus-2, Nepeta.
42. *Mesograpta marginata* (Say). Carroll, Delaware, Gibson, Marshall, Montgomery, Spencer, Tippecanoe, Tipton. April 28-Sept. 16. Claytonia; Medicago-1,1; Trifolium; Ricinus; Euphorbia-2; Euonymus-2; Malva-2; Gypsophila; Pastinaca; Daucus; Agastache-1,1,3; Pycnanthemum; Mentha-1,1; Leonurus-2; Eupatorium; Solidago; Taraxacum-1,2,8.
43. *Mesograpta polita* (Say). Tippecanoe. April 19. Salix.
44. *Metasyrphus lapponicus* (Zett.). Grant, Tippecanoe. April 3-27. Salix; Prunus.
45. *Metasyrphus perplexus* (Osb.). Tippecanoe. April 19. Mertensia.

46. *Metasyrphus wiedemanni* (Johns.). Gibson, Grant, Tippecanoe. April 1-June 16. Salix-2; Prunus-1,2; Stellaria-1,3,2; Paeonia-15; Gyypsophila; Lonicera-2; Pastinaca; Taraxacum-3.
47. *Metasyrphus* sp. Tippecanoe. April 20-June 3. Melilotus; Amygdalus-2.
48. *Paragus bicolor* (F.). Tippecanoe, Warren. July 13-Sept. 16. Brassica; Solidago.
49. *Pipiza* sp. Tippecanoe. July 15. Agastache.
50. *Platycheirus* sp. Grant. April 27. Prunus.
51. *Sphaerophoria cylindrica* (Say). Carroll, Grant, Montgomery, Tippecanoe. April 24-Sept. 12. Prunus-1,2; Leonorus; Pastinaca-2; Agastache-2; Eupatorium-1,1; Solidago; Taraxacum.
52. *Sphaerophoria menthrastri* (Linn.). Tippecanoe. April 29. Taraxacum.
53. *Spilomyia longicornis* Loew. Montgomery. Sept. 9. Eupatorium.
54. *Syritta pipiens* (Linn.). Fulton, Montgomery, Spencer, Tippecanoe. July 7-Sept. 12. Raphanus; Brassica; Eryngium; Daucus-1,4; Asclepias; Mentha-1,2; Eupatorim-1,1.
55. *Syrphus rectus* O.S. Tippecanoe. April 21-July 7. Pyrus; Daucus.
56. *Syrphus ribesii* Linn. Tippecanoe. April 19-21. Pyrus-1,2.
57. *Syrphus torvus* O.S. Grant, Madison, Tippecanoe. April 6-28. Salix-3,4; Claytonia; Pyrus; Prunus; Taraxacum.
58. *Syrphus* spp. (sen.lat.). Gibson, Tipton, Stellaria; Taraxacum.
59. *Tubifera aenea* (Scop.). Carroll, Tippecanoe, Tipton. April 5-July 27. Salix; Stellaria-1,2; Asclepias; Mentha; Taraxacum-1,1.
60. *Tubifera arbustorum* (Linn.). Grant, Montgomery, Tippecanoe. April 5-Sept. 9. Salix-1,1,1; Stellaria-1,1; Brassica; Malus; Prunus-5; Trifolium; Gypsophila; Eryngium-4; Mentha-10 collections of 1 to 6 specimens; Agastache-2; Daucus-2; Pastinaca-2,3,17; Eupatorium-2.
61. *Tubifera dimidiata* (Wied.). Tippecanoe, Warren. April 1-Sept. 16. Salix-5,5, 10, 17,5,1; Stellaria-2; Prunus; Euonymus-4; Solidago-1,1.
62. *Tubifera latifrons* (Loew). Tippecanoe. April 5-July 25. Salix; Agastache-2; Mentha.
63. *Tubifera tenax* (Linn.). Carroll, Tippecanoe. June 26-Aug. 18. Cephalanthus; Agastache; Taraxacum-2.
64. *Tubifera transversa* (Wied.). Clark, Tippecanoe. April 5-July 30. Stellaria; Mentha; Daucus; Agastache; Chrysanthemum.
65. *Tubifera vinetorum* (Fab.). Tippecanoe. July 29. Mentha.

36. PHORIDAE

66. *Megaselia* sp. Tippecanoe. June 19. Trifolium.

40. CONOPIDAE

67. *Myopa vesiculosa* Say. Tippecanoe. April 19-May 10. Salix-1,2; Malus-2.
68. *Occemyia propinqua* (Aldrich). Tippecanoe. Aug. 16. Raphanus-2.
69. *Physocephala sagittaria* (Say). Tippecanoe. Aug. 31. Mentha.

70. *Physoconops brachyrhynchus* Macq. Marshall, Montgomery, Tippecanoe. Aug. 23-Sept. 9. Euphorbia; Mentha-1,1; Eupatorium-2.
71. *Physoconops* sp. Gibson. July 12. Pycnanthemum.
72. *Zodion perclongum* Coq. Carroll, Tippecanoe. June 16-July 23. Agastache; Sambucus.

42. OTITIDAE

73. *Chrysomyza demandata* (Fab.). Tippecanoe. July 7. Pastinaca.
74. *Delphinia picta* (Fab.). Tippecanoe. Sept. 5. Ricinus-2.
75. *Tetanops integra* Lw. Tippecanoe. May 21-June 16. Pastinaca; Gypsophila-1,1.
76. *Tetranops luridipennis* Lw. Tippecanoe. June 16-Aug. 25. Ricinus-2; Euonymus-2.

50. SEPSIDAE

77. *Saltella scutellaris* (Fall). Carroll, Clinton, Madison, Spencer, Tippecanoe. April 27-Sept. 10. Gypsophila-1,1; Eupatorium-3; Calendula; Taraxacum-1,2,4.
78. *Sepsis neocynipsea* M. & S. Tippecanoe. April 19. Salix; Pyrus.
79. *Sepsis biflexuosa curvitibia* M. & S. Madison. April 28. Taraxacum.
80. *Sepsis punctum* (Fab.). Tippecanoe. May 22-July 7. Paeonia; Pastinaca.
81. *Themira putris* (Linn.). Tippecanoe. April 5. Salix.
82. *Themira nigricornis* Meigen. Tippecanoe. April 5. Stellaria.

54. SCIOMYZIDAE

83. *Dictya* sp. Tippecanoe. April 5. Salix.
84. *Sepedon fuscipennis* Lw. Tippecanoe. Oct. 14. Aster.

64. OCHTHIPHILIDAE

85. *Leucopis* sp. Tippecanoe. May 22. Poeonia.

65. AGROMYZIDAE

86. *Tylomyza madizina* (Hend.). Tippecanoe, Tipton. April 28-July 30. Taraxacum; Daucus.

66. PHYLLOMYZIDAE

87. *Desmometopa tarsalis* (Lw.) Spencer. Sept. 11. Solidago.
88. *Milichiella lacteipennis* (Lw.). Tippecanoe. Sept. 10. Ricinus.
89. *Leptometopa latipes* (Mg.). Tippecanoe. July 7. Daucus.

70. EPHYDRIDAE

90. *Lyogaster gravida excavata* (S. & W.). Tippecanoe. April 19. Salix.

71. CHLOROPIDAE

91. *Madiza setulosa* Mall. Tippecanoe. June 19. Trifolium.
92. *Madiza cinerea* (Lw.). Carroll. July 23. Asclepias-1.
93. *Elachiptera costata* (Lw.). Tippecanoe. April 1. Salix.

77. TACHINIDAE

94. *Allophorella aenoventris* (Will.). Montgomery, Tippecanoe. June 3-Oct. 14. Euonymus; Eupatorium-1,3; Aster-3.
95. *Alophorellopsis purpurascens* (Tns.). Tippecanoe. May 21-Aug. 31. Mentha-2; Gypsophila.
96. *Archytas apicifer* (Walk.). Carroll, Cass, Marshall, Montgomery, Morgan, Tippecanoe. June 9-Sept. 18. Polygonum-3; Melilotus-4 collections of two to many each; Trifolium; Eryngium-1,1,1; Asclepias-1,2,29; Mentha-8 collections of 1 to 6 each; Eupatorium-+,+,1; Solidago; Taraxacum.
97. *Archytas basifulvus* Walk. Morgan. July 15. Melilotus.
98. *Archytas metallica* (R.D.). Montgomery. Sept. 12. Solidago.
99. *Blepharigenia spinosula* Big. Tippecanoe. July 7. Daucus.
100. *Bonnetia comta* (Fall). Montgomery, Tippecanoe. July 26-Oct. 14. Mentha; Daucus; Eupatorium; Aster.
101. *Chaetophagia atripennis* Coq. Tippecanoe. June 9. Lotus.
102. *Cylindromyia binotata* (Big.). Tippecanoe. Aug. 13. Mentha.
103. *Cylindromyia decora* Ald. Tippecanoe. Aug. 31. Mentha.
104. *Cylindromyia fumipennis* (Big.). Montgomery, Tippecanoe. Sept. 12-Aug. 13. Mentha; Eupatorium.
105. *Cylindromyia* sp. Marshall. Aug. 23. Euphorbia.
106. *Epalpus signifer* (Wlk.). Tippecanoe. April 5. Salix.
107. *Euclytia flava* Tns. Montgomery. Sept. 12. Eupatorium.
108. *Gonia frontosa* Say. Grant, Madison, Tippecanoe. April 1-28. Salix-6 collections of 1 to 11 each; Claytonia-2; Stellaria.
109. *Gonia sequax* Will. Montgomery. Sept. 12. Eupatorium.
110. *Gonia* sp. Tippecanoe. April 20-21. Claytonia; Taraxacum.
111. *Gymnoclytia occidua* (Walk.). Clark, Montgomery, Spencer, Tippecanoe. June 8-Sept. 12. Euonymus; Pastinaca-1,2; Mentha-1,1,2; Eupatorium-1,2,1; Chrysanthemum.
112. *Gymnosoma fuliginosa* R.D. Spencer. Sept. 11. Polygonum.
113. *Gymnosoma occidentae* Curr. Tippecanoe. July 30-Aug. 31. Mentha; Daucus.
114. *Gymnosoma* sp. Tippecanoe. May 23. Gypsophila.
115. *Hyalomyodes tranqulifera* (Lw.). Montgomery, Spencer, Tippecanoe. June 8-Sept. 10. Euonymus; Eupatorium-1,2.
116. *Leucostoma gravipes* (Wulp). Tippecanoe. May 21. Gyphophila.
117. *Leucostoma simplex* (Fall.). Montgomery. Sept. 9. Eupatorium.
118. *Myiophasia nigrifrons* (Tns.). Montgomery. Sept. 9. Eupatorium-2.
119. *Myiophasia* sp. Montgomery, Tippecanoe. July 7-Sept. 9. Asclepias; Eupatorium.
120. *Oedematopteryx fumosa* (Coq.). Tippecanoe. June 19-Aug. 2. Pastinaca; Mentha.
121. *Paraphasia fenestrata* (Big.). Tippecanoe. April 12. Salix.
122. *Phorocera claripennis* Macq. Montgomery, Tippecanoe. April 14-Sept. 9. Salix; Eupatorium.
123. *Tachinomyia apicata* Curr. Tippecanoe. April 6-21. Stellaria; Pyrus.

124. *Trichopoda pennipes* (Fabr.). Montgomery, Tippecanoe. Aug. 3-Sept. 12. Mentha-1,1; Eupatorium.
125. *Winthemia* sp. Marshall, Tippecanoe. June 16-Aug. 9. Trifolium; Eupatorium.

78. CALLIPHORIDAE

126. *Bufolucilia silvarum* (Mg.). Tippecanoe. June 3-July 7. Pastinaca; Daucus-2; Asclepias; Salvia.
127. *Calliphora vomitoria* (Linn.). Tippecanoe. April 5. Stellaria.
128. *Callitroga macellaria* (Fabr.). Carroll, Cass, Gibson, Montgomery, Spencer, Tippecanoe. July 12-Sept. 9. Melilotus; Ricinus; Daucus; Mentha-1,8; Eupatorium-+,+; Solidago.
129. *Cynomyopsis cadaverina* (R.D.). Grant, Tippecanoe. April 6-Oct. 19. Salix-1,2,4; Stellaria-3; Pyrus; Aster.
130. *Lucilia illustris* Mg. Tippecanoe. June 3-July 7. Euonymus; Daucus.
131. *Phaenicia caeruleiviridis* (Macq.). Spencer, Tippecanoe. June 19-Sept. 10. Pastinaca; Solidago.
132. *Phaenicia sericata* (Mg.). Cass, Fulton, Montgomery, Tippecanoe. May 22-Sept. 18. Ricinus; Euonymus; Eryngium; Pastinaca; Paeonia; Asclepias; Mentha; Eupatorium-3,3.
133. *Phormia regina* (Mg.). Grant, Tippecanoe. April 4-27. Stellaria; Pyrus; Prunus-2; Paeonia-2; Elaeagnas.
134. *Pollenia rudis* (Fabr.). Carroll, Grant, Montgomery, Tippecanoe, Tipton. April 5-Sept. 9. Salix-1,7,3; Prunus-7; Eryngium-3; Malva-6,1; Pastinaca; Daucus-5; Asclepias-7,3; Agastache-1,2,1,1; Nepeta-2; Mentha-1,1,2; Eupatorium-3; Taraxacum-1.
135. *Protocalliphora* sp. Grant. April 27. Prunus.

79. SARCOPHAGIDAE

136. *Amobia erythrura* Wulp. Montgomery. Sept. 9. Eupatorium-3.
137. *Oestrohilarella aristalis* (Coq.). Tippecanoe. June 8. Euonymus.
138. *Sarcophaga bullata* Pk. Montgomery. Sept. 12. Eupatorium.
139. *Sarcophaga derelicta* (Walk.). Montgomery, Tippecanoe. May 22-Sept. 12. Paeonia-2; Solidago.
140. *Sarcophaga hunteri* Hough. Spencer. Sept. 10. Ricinus.
141. *Sarcophaga impar* Old. Montgomery. Sept. 9-12. Eupatorium-1,1.
142. *Sarcophaga lherminieri* R.D. Montgomery. Sep. 9-12. Eupatorium-1,6.
143. *Sarcophaga querula* Walk. Carroll, Tippecanoe. May 9-Oct. 19. Aster; Taraxacum-1,1.
144. *Sarcophaga (Heliobia) rapax* Walk. Montgomery, Tippecanoe. June 3-Sept. 12. Lotus; Phaseolus; Euonymus-1,3; Pastinaca; Daucus-3; Mentha-2; Eupatorium-11,3; Solidago.
145. *Sarcophaga riversa* Ald. Jasper. Aug. 27. Eupatorium-2.
146. *Sarcophaga sarracenioides* Ald. Tippecanoe. Sept. 21. Taraxacum.
147. *Sarcophaga ventricosa* Wulp. Paeonia-2; Eupatorium-1,5.
148. *Sarcophaga (Acridiophaga)* sp. Marshall, Tippecanoe. July 7-Aug. 23. Asclepias; Euphorbia.
149. *Sarcophaga (Chaetoravinia)* sp. Tippecanoe. June 24. Agastache.

150. *Sarcophaga* spp. Knox, Tippecanoe. April 5-Aug. 25. Salix; Trifolium; Phaseolus; Paeonia; Agastache.
151. *Senotainia flavicornis* (Tns.). White. Aug. 9. Eryngium-2.
152. *Senotainia rubriventris* Macq. Marshall. Aug. 23. Euphorbia.
153. *Senotainia trilineata* (Wulp.). Marshall, Spencer, Tippecanoe, White. July 30-Sept. 5. Euphorbia-1,2; Eryngium; Daucus-2; Mentha-1,1; Eupatorium; Solidago.
154. *Senotainia* sp. Montgomery. Sept. 9. Eupatorium.
155. *Wolfahrtia vigil* (Walk.). Cass. Sept. 18. Solidago.

80. MUSCIDAE

156. *Graphomya maculata* (Scop.). Spencer, Tippecanoe, White. June 3-Sept. 16. Euonymus; Eryngium; Mentha; Solidago-1,1.
157. *Helina rufitibia* (Stein.). Tippecanoe. April 5-12. Salix-1,1,1; Lonicera.
158. *Hydrophoria implicata* Huck. Tippecanoe. July 7. Daucus.
159. *Hylemya cilicrura* (Rond.). Clinton, Delaware, Grant, Madison, Tippecanoe, Tipton. April 3-July 7. Salix-1,4,3,6,1,16,6; Stellaria-1,2; Pyrus-5; Prunus-9,16; Pastinaca-3; Daucus-1,2; Paeonia-6; Gypsophila; Agastache; Salvia-1,1; Taraxacum-1,23.
160. *Morellia micans* (Macq.). Tipton. April 29. Taraxacum.
161. *Musca domestica* Linn. Montgomery, Tippecanoe. May 22-Sept. 9. Pastinaca; Daucus; Gypsophila; Eupatorium.
162. *Orthellia caesarion* (Mg.). Carroll, Cass, Grant, Montgomery, Tippecanoe, White. April 5-Sept. 18. Salix-1,2; Prunus-7; Paeonia-2; Euonymus-2; Eryngium; Asclepias; Eupatorium; Solidago.
163. *Paregle cinerella* (Fall.). Clinton, Delaware, Grant, Madison, Montgomery, Tippecanoe, Tipton. April 19-Sept. 12. Salix-7; Claytonia-5; Pyrus 9; Prunus; Paeonia; Gypsophila; Malva; Mentha; Taraxacum-1,12,5.
164. *Stomoxys calcitrans* (Linn.). Montgomery. Sept. 9. Eupatorium.

82. SCOPEUMATIDAE

165. *Scopeuma furcatum* (Say). Tippecanoe. April 1-14. Salix-1,8,2; Pyrus-5.
166. *Scopeuma stercorarium* (Linn.). Carroll. July 25. Asclepias.

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A Large Aggregation of Larval Millipeds, *Zinaria butleri* (McNeill), in Brown County, Indiana[1]

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Early on the morning of June 9, 1957, Mrs. Melvin Carter, of Nashville, Indiana, called the writer in regard to a large aggregation of millipeds on her property near Gnawbone. The millipeds were reported to be lying in a strip about 12 feet wide by 25 feet long and in places piled to a height of 4 to 5 inches.

By 3 p.m. that afternoon, when the writer reached the locality, the dense aggregation had dispersed, but millipeds were still abundant at the surface. When the dead leaves on the forest floor were lifted, hundreds were uncovered feeding and moving about at every point examined over an area about 30 feet long by 20 feet wide. In places in which the leaf mat was intact one could hear the millipeds feeding below, and the whole area had a distinct odor of crushed cherry leaves due to the HCN gas released from the repugnatorial glands of the millipeds.

Dr. Nell B. Causey of the University of Arkansas kindly determined the species as *Zinaria butleri* (McNeill, 1888). The aggregation consisted primarily of light colored larvae in the last stadium mixed with a few fully colored adults and uncolored adults which had apparently only recently shed the last larval skin.

Large aggregations of *Z. butleri* are not uncommon, and according to Dr. Causey, seem to occur a year or two after a season that has been favorable for reproduction. Williams (1951) reports an unusual aggregation of adults, but large aggregations of larvae do not seem to have been noted in Indiana.

The aggregation in Brown County was on the upper slopes of a steep hill and seemed to center around a shallow drainage course. All millipeds seen in the afternoon were under or very close to the shaded portions of a cut-over woodland in which white and black oak, various species of hickory, red bud, sassafras, and sumac predominated. The forest floor was covered with a mat of leaves, apparently riddled by the feeding of the millipeds. *Desmodium* and some poison ivy were the only low vegetation in the area.

A number of the millipeds were brought back to the laboratory for study and several rough experiments were performed in an attempt to explain the concentration observed. It is apparent that *Zinaria,* like many other arthropods, moves more rapidly in dry air and slows down in moist air. Also they show a tendency to cling to another milliped whenever contact is made. When a moisture gradient is established the millipeds tend to concentrate in the area of greater moisture, and if some physical obstacle is interposed they pile up against it.

It was impossible to determine whether the aggregation observed in Brown County had developed in situ or the individuals had migrated from some other place in the area. The damage to the leaves suggests, however, that they had been there for some time. The dense aggregation observed by Mrs. Carter may have been due to the "trapping action" of higher humidity in a narrow strip associated with the shallow drainage course, and may have been preliminary to a migration out of the area.

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[1] Contribution No. 641 from the Zoological Laboratories of Indiana University.

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The Ten Most Important Plant Feeding Pests in Indiana

G. E. Lehker, Purdue University

On first thought, it might seem not too difficult to prepare a list of the ten most important plant feeding insects in Indiana. The entomology staff at Purdue University, along with those in other states, was asked to prepare such a list for use by the Agricultural Research Service of the U. S. Department of Agriculture. Results of this nationwide survey are published in Volume 7, number 21 of the Cooperative Insect Report issued by the above named agency.

The Purdue Staff reached a general agreement on about twenty insects but beyond this there was marked disagreement as to those of most importance and the order in which they should be listed. This is what one would expect, since there is no scientific data on which to base such selections and it thus becomes largely a matter of personal opinion. Then, too, there are many sets of criteria which can be applied to the making of such a list. For example, what is an important insect? Should the list be confined to individual species, or should it include closely related groups such as cutworms and aphids? Would not a minor pest of a widely grown crop such as corn, be more important than a major pest of a minor crop? Are control measures available and, if so, how practical are they and to what extent are they used? Since insect populations fluctuate widely, should the selections be based on a single year or on a period of years? Should related forms, such as mites, be included? How important are shade trees and plants of an asthetic value in comparison with those upon which people depend for a living? These are only a few of the criteria considered, but be as it may, here is our list of insects (and one mite) along with some reasons for including them.

1. **Corn Earworm** *Heliothis zea* (Boddie)—This pest is of major importance on a widely grown crop. It also attacks tomatoes and tobacco in this area. It maintains a high level of abundance, and on field corn no practical control measures are available.

2. **Potato Leafhopper** *Empoasca fabae* (Harr.)—This is a general feeder responsible for most alfalfa yellowing and "tip burn" or "hopper blight" on potatoes. It is also an important pest of apples, soybeans, clover, garden beans and many flowers and shrubs.

3. **European Corn** *Borer Pyrausta nubilalis* (Hbn.)—Corn borer populations and damage fluctuate greatly from year to year, but it is difficult to exclude this pest because of the great importance of corn to the economy of Indiana.

4. **Cutworms** family Noctuidae—These insects were considered as a group because of their close relationship and similarity of habits and control. They are general feeders, more or less abundant every year,

and damage many important crops including corn, legumes, pastures, vegetables and tobacco.

5. **Smaller European Elm Bark Beetle** *Scolytus multistriatus* (Marsh.)—This insect is the primary vector of the Dutch elm disease and is therefore indirectly responsible for the vast sums of time and money now being spent for the removal and replacement of diseased trees.

6. **Meadow Spittlebug** *Philaenus leucophthalmus* (L.)—The spittlebug is a major pest of alfalfa and clover and sometimes causes losses ranging up to 50 percent of the crop. It is not difficult to control and many crop sprayers have been purchased with this use in mind. The spittlebug is also an important pest of strawberries.

7. **Two-Spotted Spider Mite** *Tetranychus telarius* (L).—This mite is the one commonly referred to as the "red spider". It is a general feeder and causes extensive damage to apples and to a variety of trees, shrubs, small fruits, vegetables and flowers.

8. **Coddling Moth** *Carpocapsa pomonella* (L)—This insect is responsible for a great majority of "wormy apples". It is a specialized feeder on a minor crop but was included because it usually destroys the crop in both home and commercial orchards unless time-consuming and costly control measures are applied.

9. **Hessian Fly** *Phytophaga destructor* (Say)—This pest of wheat is always present and is held in check by a general observance of the fly free date for seeding wheat. Even so, it causes considerable damage in some years.

10. **Aphids** family Aphididae—Here again, aphids are considered as a group and as such they are among the most common insects in Indiana. The various species feed on a variety of important crops or plants including legumes, corn, vegetables, fruits, trees, shrubs and flowers.

GEOLOGY AND GEOGRAPHY

Chairman: THOMAS G. PERRY, Indiana University

JOHN FRASER HART, Indiana University, was elected chairman for 1958

ABSTRACTS

Stromatoporoid and Coral Reefs in Indiana. J. J. GALLOWAY, Indiana University.—It is likely that Indiana has more organic reefs or bioherms than any other similar area in the world. The reefs of Indiana are in Paleozoic rocks, of Ordovician, Silurian and Devonian age. They are largely composed of Stromatoporoids, with few to many corals; the corals are the conspicuous fossils, for stromatoporoids look mostly like mere chunks of rocks. The organisms grew as great colonies, and grew up to the level of the water at high tide, for the specimens are often found overturned and broken, indicating wave action. Corals and stromatoporoids could withstand the breakers, and they sheltered other organisms, such as Algae, Mollusca, Bryozoa, Brachiopods and Foraminifera.

The oldest reef in Indiana is a layer of stromatoporoids in the Whitewater formation (Upper Ordovician) in the big cut in Road 56 near Hanover. It is only 3 or 4 feet thick, and consists entirely of one species of stromatoporoids, *Labechia huronensis*. Large corals, *Favistella stellata*, occur in profusion in the Saluda limestone (Upper Ordovician) at Clifty Falls and in the north cut at Madison, but they do not make convex masses qualifying as reefs.

The most abundant reefs are in the Silurian. Cumings and Shrock (1928) have identified and located on a map over fifty reefs in the various parts of the Silurian rocks of Indiana. The reefs are made up mainly of stromatoporoids, of the genera *Stromatopora* and *Clathrodictyon*, but in places there are also corals, brachiopods, molluscs and trilobites. In other places, as at the famous reef at the Big Four station at Wabash, the fossils have been largely recrystallized so that they cannot be identified. Dolomitization is common in the reefs as well as in inter-reef rock.

Devonian reefs are not abundant in Indiana, but they are of large size, and the most famous reef in America, that at the Falls of the Ohio at Jeffersonville, is made up entirely of stromatoporoids at some levels, while in the lower part corals and stromatoporoids occur in profusion. The corals lie helter-skelter, and some large heads of stromatoporoids more than a foot across now occur upside down, showing that the reef was in very shallow water. Cumings (1922) has compiled a list of over 500 species of fossils from that reef; he does not consider the occurrence at the Falls of the Ohio to be a reef or bioherm, but an extended bed of organic limestone, or biostrome. Galloway and St. Jean have recently (1957) described 9 species of stromatoporoids from that occurrence, and there may be many more.

A very large Devonian reef occurs five miles east of Logansport, Indiana. Here a large quarry has been developed, consisting very largely of stromatoporoids. Galloway and St. Jean have described 20 species of stromatoporoids from a lower bed 10 feet thick, having no other identifiable fossils, and have described 9 different species from an upper mass of fossils 20 feet thick. The upper mass also cotains abundant corals but few other kinds of fossils. A small Devonian reef occurs at Pipe Creek Falls, 10 miles southeast of Logansport, the type locality of the Logansport limestone. A bed of limestone 3 or 4 feet thick, composed entirely of the spaghetti-like stromatoporoid *Amphipora ramosa*, occurs in the Independent Quarry, 4 miles south of Dupont, Indiana; such an occurrence can scarcely be called a reef. Great Devonian reefs, largely composed of stromatoporoids, occur in Michigan, from which, according to Alexander Winchell, shiploads of stromatoporoids, some specimens 12 feet in diameter, have been quarried, crushed and used as a flux in the making of steel.

The crushed rock, taken from reefs is used in Indiana for road metal, concrete, lime, and mineral wool, and oil has been found in Devonian reefs in western Indiana. Reefs have become important in the last ten years as reservoirs for petroleum in the Indiana-Illinois Basin, Texas, and western Canada. The stromatoporoids of reefs deserve more study to be used in correlation, including inter-continental correlation.

Geologic Observations on Southampton Island, N. W. T. WILLIAM J. WAYNE,[1] Indiana Geological Survey.—One problem in the study of Pleistocene glaciations in Indiana is to learn more about the climates that existed along the margins of continental glaciers that reached these lower latitudes. A geologic objective of the Indiana Gear Works Expedition to Southampton Island, N. W. T., in August 1957, related to this problem was to make observations on the geomorphic processes and biologic phenomena in an area of tundra that might be compared with some of the features encountered in Pleistocene sediments in Indiana.

Southampton Island lies between lat. 63°N. and lat. 66°N. and is directly north of eastern Indiana. Mean annual temperature is about —13°C (8°F), mean July temperature is about 7°C (45°F), and average annual total precipitation is 12 inches. Ground temperature below the top few feet is continuously below freezing. Solifluction features and patterned ground are everywhere present.

Pre-Cambrian gneisses are fairly well exposed in the northern part of the island, but limestone and glacial drift exposures are restricted to sea cliffs and river banks where frost-shattered debris is quickly washed away. Much of the island was submerged during late Pleistocene time, and virtually all glacial deposits examined showed evidence of marine sedimentation as well as post-depositional disturbance by solufluction and frost. Silurian bioherms were exposed on the tidal flat near Manico Point and near Renny Point. Interbiohermal strata are flat-lying thin- to medium-bedded limestone and are moderately fossiliferous locally.

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Industrial Minerals in Indiana's Economy.[1] DUNCAN J. MCGREGOR, Indiana Geological Survey.—Indiana's industrial minerals include crushed limestone and dolomite, dimension stone, sand and gravel, clay and shale, high silica sand and gravel, gypsum, cement, marl, whetstones and peat.

The total value of these mineral commodities in 1955 was $117,275,458 (U. S. Bureau of Mines). If the value of petroleum and coal is added to this figure the total value of Indiana's mineral products is $211,810,458. Indiana ranks 20th among the 48 states and Alaska in total value of mineral production.

Industrial Mineral Resources of Washington County, Indiana.[2] JACK A. SUNDERMAN,[3] Indiana Geological Survey.—Mississippian shales, silt stones, sandstones, and limestones, the Ohio River sands, some small argillaceous sand bodies, glacial sands and gravels, glacial lake clays and silts, and residual clays constitute potential mineral resources in Washington County, Indiana.

In previous years, mineral raw materials have been quarried from the Borden siltstones and sandstones, from the Harrodsburg, Salem, and Ste. Genevieve limestones, and from the Sample sandstone. Material also has been dug from the Ohio River sands, from other sand bodies found in the county, and from glacial sands and gravels.

Unfavorable locations of pit and quarry sites, poor quality of some of the raw materials extracted, and other economic factors have forced abandonment of all operations in the county with the exception of one large limestone quarry in the Harrodsburg, Salem, and St. Louis limestones.

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[2] Published by permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

[3] Geologist, Industrial Minerals Section, Indiana Geological Survey, Bloomington, Indiana.

Effect of Geologic Processes on Economic Resources of Late Paleozoic Rocks of Indiana

T. G. Perry, Indiana University

Geologists and geographers are interested in different aspects of our natural resources. Geologists are concerned primarily in locating natural resources and in studying the geologic conditions under which they were formed. Geographers, in contrast, probably are most interested in their conservation, their location with respect to manufacturing areas, and economic conditions which permit their exploitation and development. It is desirable that my retiring address should appeal to both factions of this Division, geologists and geographers; presumably comments on natural resources, a common meeting ground of geologists and geographers, will interest both groups. I plan, therefore, to discuss one aspect of our natural resources, namely the manner in which some geologic processes have adversely affected our natural resources in local areas of Indiana.

Geologic processes include all operations or forces which modify or contribute to the material forming the crust of the earth. Such processes would include metamorphism by which pre-existing rocks are highly altered as a result of heat and pressure as well as chemical action; erosion by which pre-existing topography is changed due to the activity of running water, glacial ice, wind, and other erosional agents; weathering by which rocks are decomposed slowly under the attack of atmospheric agents; and sedimentation, the process involving the deposition and accumulation of such sedimentary rocks as limestone, shale, and sandstone.

I now wish to focus attention on rocks of late Mississippian age which crop out in a northwesterly trending area from the Ohio River to the vicinity of Greencastle, Indiana. These rocks (Fig. 1) form the Chester series and consist of alternating limestone and sandstone or shale formations. Several Chester limestones are sufficiently thick to quarry, notably the Beech Creek, Golconda, and Glen Dean. Quarries in Chester limestones are strategically located geographically because Pennsylvanian rocks, which lie immediately west of the Chester outcrop belt, do not contain limestones of sufficient thickness for commercial quarrying. Hence, the area west of a quarry located in a Chester limestone generally affords a ready market for the quarry's products.

The shallow seas in which Chester rocks were deposited in late Mississippian time withdrew southward at the close of this period. Destructive erosional forces instantly began their attack on a terrane underlain by recently deposited late Mississippian rocks. As a result, a topography reminiscent of that now found in Crawford and western Orange Counties, Indiana, was developed on this post-Mississippian land surface. Therefore, erosion destroyed the lateral continuity of Chester limestones which are quarried today for crushed stone and agricultural

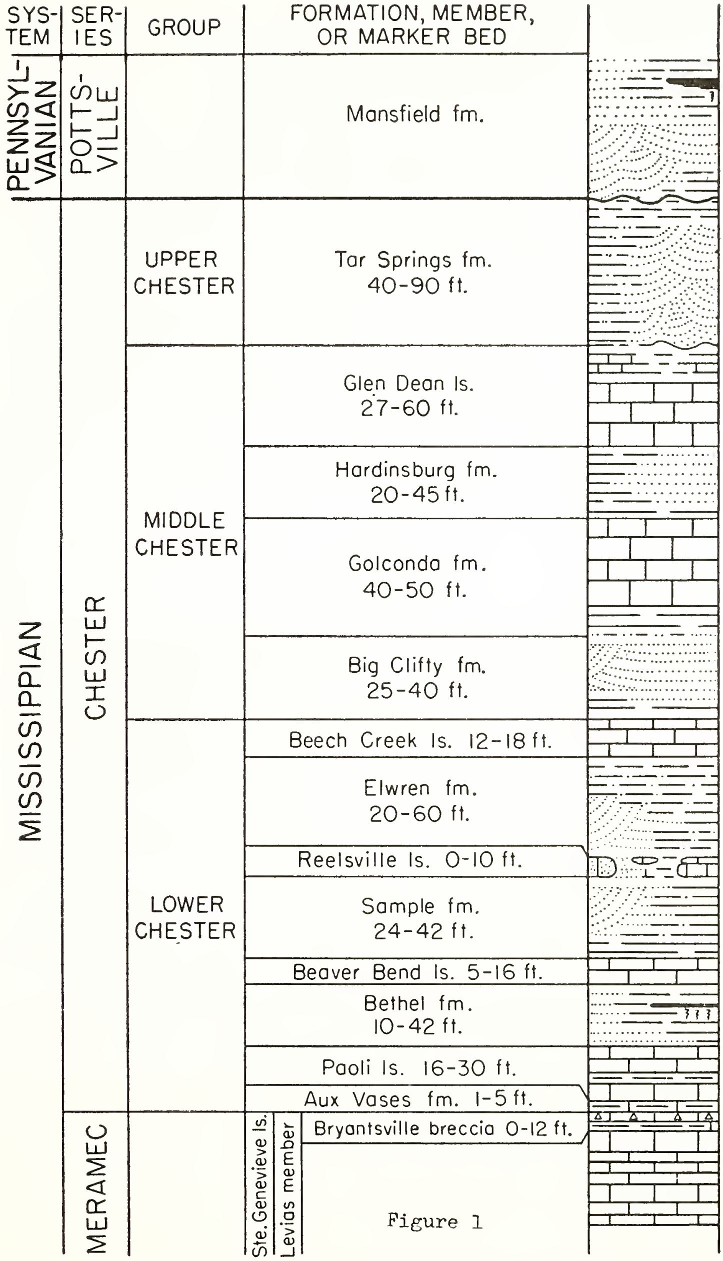

Figure 1. Columnar section showing part of Chester series (late Mississippian) and basal portion of Pottsville series (early Pennsylvanian).

lime. As a result, quarry sites in Chester limestones which are near the Mississippian-Pennsylvanian boundary should be proved by drilling or critically examined by a geologist before quarrying operations are initiated. As an example of this statement, several years ago I investigated a potential quarry site about one mile north of the village of Atkinsonville in northern Owen County, Indiana. Here the Beech Creek limestone attained the impressive thickness of nearly 25 feet and was well exposed near the top of a broad, flat-topped knoll of considerable extent so that removal of overburden would not be a formidable or expensive task. On cursory examination, the site appeared ideal. A more detailed examination, however, showed that, less than 200 yards from the Beech Creek exposure, the topographic level of the Beech Creek was occupied by sandstone of Pennsylvanian age. Thus, vagaries of pre-Pennsylvanian erosion permitted local preservation of this remnant of the Beech Creek limestone. Had quarrying operations begun at this site, the operator would have soon been confronted with the embarrassing situation of rapidly exhausting the available limestone. Thus, erosion, a widespread geologic process, here has adversely but locally affected this formation as a source of crushed stone and agricultural lime.

A controversial geologic section (1) is exposed in the abandoned quarry of the French Lick Sandstone Company in the NW¼NW¼ sec. 28, T. 2 N., R. 2 W., 1.5 miles west of the village of Prospect and 0.5 mile south of U. S. Highway 150, in western Orange County, Indiana. Here a geologic section consisting entirely of sandstone intervenes between the top of the Beaver Bend limestone and the base of the Beech Creek limestone. The Reelsville limestone is not represented in this section. The absence of the Reelsville may be attributed to pre-Pennsylvanian erosion; under this interpretation, the massive, cliff-forming sandstone would represent a channel fill deposit, as is suggested particularly by the prominence and direction of the cross-bedding in this exposure, formed in a stream that carved its valley in a late Mississippian terrane. In contrast, sedimentation conditions may have militated against deposition of Reelsville limestone in this locality; elsewhere, particularly in east-central Owen County, conditions of sedimentation did not permit deposition of Reelsville limestone (4). Further, either because of post-Reelsville erosion or abrupt facies changes (3), the Reelsville limestone shows abrupt lateral discontinuity (Fig. 2) as is shown in an exposure in the NE¼SW¼ sec. 5, T. 3 N., R. 2 W., along the Baltimore and Ohio Railroad 0.5 mile east of the village of Huron in Lawrence County, Indiana.

Regardless of what geologic process brought about the absence of the Reelsville limestone in the French Lick Sandstone Company section, the immediate area of this prospective quarry site should be carefully scrutinized by drilling prior to its further development as a dimension stone quarry. As quarrying operations would proceed southeastward, the operator may conceivably encounter the Reelsville limestone in a short distance, which circumstance would probably militate against continued exploitation of this site for dimension stone. Here again, one of two

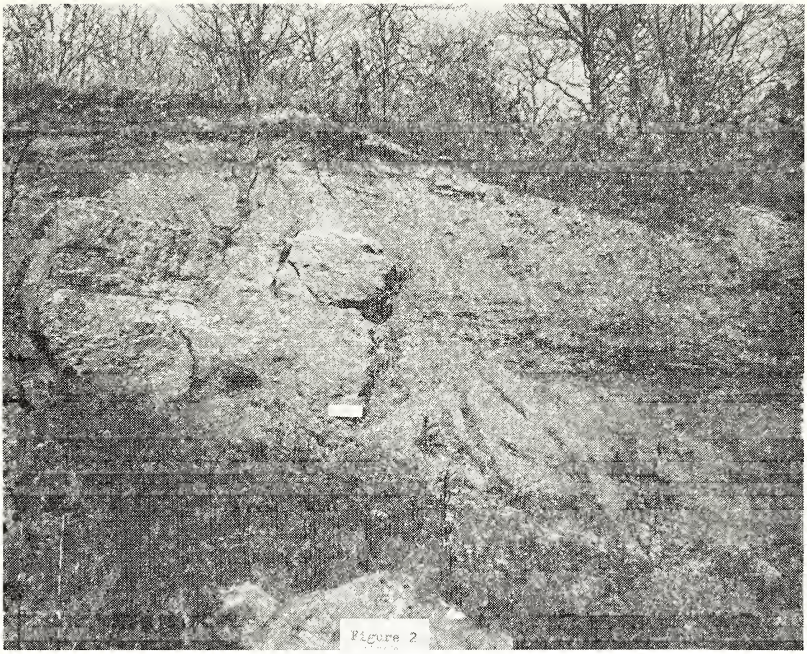

Figure 2. Reelsville limestone in railroad cut near Huron, Indiana. Limestone, 8 feet thick, in west (left) side of photograph is laterally continuous westward for more than 100 yards; eastward (right) limestone abruptly gives way laterally to olive-gray silty shale. Scale card is 1 foot wide.

common geologic processes, erosion or vagaries of sedimentation conditions, has affected one of Indiana's natural resources, dimension stone.

Now let us finally turn our attention to the youngest Paleozoic rocks of Indiana which were deposited during the Pennsylvanian period when flourishing vegetation in extensive swamps supplied the basic materials for the formation of a very vital natural resource, coal. Only those nations which have an abundant supply of coal within their boundaries or ready access to coal in neighboring countries have risen to industrial prominence.

Pennsylvanian rocks in Indiana contain several distinct mineable coal beds, which are generally indicated by numerical designation. One of these is Coal V which is found in Vigo County and elsewhere in Indiana. Geologic processes have rendered this coal, normally about 5 feet thick, unmineable in the area of the Dresser mine in Vigo County.

Friedman (2) described in detail the geologic processes which have rendered this coal locally unmineable in the vicinity of the Dresser mine. In Pennsylvanian time in this area a stream coursed through the initial phases of peat formation in the swamp whose lush vegetation contributed to Coal V and ultimately became entrenched in shale and clay underlying this peat bog. In addition to depositing sand in its channel, the stream meandered, cut laterally, and laid down mud and fine sand in its flood plain as do modern rivers. Peat formed locally where swamp conditions advanced on the flood plain of this ancient stream. Mud, sand, and peat were deposited synchronously as is indicated by the intertonguing (interleaving) of these materials. The channel of the stream was then temporarily abandoned and was overgrown by vegetation which ultimately formed peat. Renewed stream activity on this site caused local erosion of the somewhat more recently formed peat. At the conclusion of this sedimentation cycle, the channel site contained about 40 feet of sand, and the peat adjoining this stream was probably of the same order of thickness. Compaction of the peat resulted in the formation of Coal V and the inferred geologic conditions now maintaining. Friedman (2) depicts the lateral extent of the area that has been rendered unmineable by two widespread geologic processes, sedimentation and erosion, shows a stratigraphic cross section through the unmineable area of Coal V, and indicates the position of closely spaced drill holes on which this geologic interpretation was based.

In conclusion, I trust that geographers now have a better realization that the potential value of many natural resources in the crust of the earth may be governed by geologic processes which were in operation scores of millions of years before man began their exploitation.

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Indiana's Probable Climate During the Glacial Period

Stephen S. Visher, Indiana University

My volumes *Climate of Indiana* (1944), *Climatic Atlas of the United States* (1954), *Climate Changes, their nature and causes* (co-author) (1922), and several papers afford considerable basis for the following surmises concerning the probable climate of Indiana during the Glacial Period.

Indiana's climate then was far less different from the present climate than most people suppose. It surely then, as now, was "continental," that is characterized by sharp contrasts between winter and summer. The summers were relatively warm much of the time, inducing rapid melting and permitting considerable vegetative growth in areas not ice-covered. The winds blowing off the icesheet were relatively cold and strong, and as their temperature rose, as they blew down off the icesheet and were warmed by the ice-free land, their relative humidity dropped sharply. Hence, they were drying winds. There is much evidence that considerable wind erosion occurred on the bare areas near the margin of the icesheets, especially when they were melting away rapidly, and their margin was retreating. Much wind erosion also occurred along the valleys of rivers whose wide floodplains were water-covered in summer but were largely bare in winter. Deposits of wind borne materials known as loess were partly a consequence of these strong winds blowing off the icesheets or of strong westerly and northwesterly winds in winter blowing across the silt-covered valleys of rivers flowing out from the icesheets. Considerable loess deposits accumulated just east of the lower Wabash Valley. When the winds blew northward onto the ice, as they very frequently did, the cooling induced by the ice and by the rise in elevation to get onto the icesheet, caused much precipitation near the ice margin. Doubtless snowfall was much heavier than now, and the rainfall heavier also. The rain falling on the ice supplemented the summer warmth to increase runoff, which was very rapid. In Indiana, many streams flowing out from the icesheets were torrents during the warmer months. The Wabash River "sluiceway" is clear evidence of this, as are the vast valley fillings downstream from the "sluice-way" and elsewhere. The very extensive deposits of glacial gravels along such Indiana valleys as the White, Whitewater, Wabash, Tippecanoe, Eel, and Kankakee are also indications of vast runoff.

Indiana's climate was clearly of the humid type, as now, rather than semi-arid or arid. Doubtless the rainfall was greater than now, and the snowfall greater during the colder months.

Then as now, there surely were frequent changes of weather from day to day, associated with the passage across the state of cyclonic disturbances or air masses. The day-to-day changes were greater than at present because winds from the north, from off the icesheet, were colder than now, while winds from the south were almost as warm as now.

The length of the frost-free or growing season doubtless was shorter than at present because of the sharp cooling that occurred for a considerable distance from the glacier as a result of the off-the-icesheet winds, which prevailed approximately a third of the time.

The air-mass fronts frequent along the glacial margin increased thunder storms and their intensity. Cloudiness was greater than at present in much of the state when southerly winds blew. But conversely, near the glacial margins, when the drying winds blew off the icesheets the sky was clear; and an almost blinding glare was reflected by day from the snow-covered areas.

Instead of the climate being much colder than at present, the average temperature of the year was only about 20 degrees lower than now, about 32° instead of 52°. When the average temperature was below 32°, the icesheet expanded, when higher than 32° it decreased. In the areas which were not ice-covered, considerable vegetation grew except where exposure was brief. This is proven by many remaining logs covered by the advancing ice. The numerous fossils found buried under glacial deposits, in bogs or in loess near the ice margins also prove that climatic conditions were less severe than many people have believed. The sizeable area in southwestern Wisconsin and small bordering parts of Minnesota, Iowa, and Illinois which was not covered by the ice contained a varied flora and fauna throughout the glacial period. There is considerable evidence that the unglaciated part of Indiana, the south-central part, was similarly inhabited. Men lived very close to the glaciers in Europe.

During the interglacial epochs, the climate differed little from the present, though one was drier and another was warmer than recent decades.

Fossil Cephalopods of Mississipian Age, Central Putnam County, Indiana

C. L. Bieber, DePauw University

Introduction.—Cephalopods in unusual numbers are localized in limestone of Meramecian age 1 mile west of Greencastle, Indiana, in the NW¼NW¼ sec. 20 and in the SW¼ sec. 17, T. 14 N., R 4 W. The fossils, which are mainly cephalopods, are packed together in coquina-like masses in light gray limestone, apparently at or near the contact of the Salem and St. Louis formations. Nautiloid cephalopods from this area were reported as early as 1873 (3), and more recently a goniatite from this location has been described (5).

Geologic setting.—Fossils for this study have been collected from two areas about one-fourth of a mile apart in sec. 17 and 20. The fossils are in limestone beds from 12 inches to 18 inches thick located stratigraphically in transition between the Salem and St. Louis formations. Vertically the fossils extend through 4 to 5 feet of rock. A few small straight nautiloids are scattered in limestone at the same horizon one-half of a mile north of Greencastle. Other fossils found sparingly in association with the cephalopod fauna are *Productus* cf. *P. altonensis*, *Spirifer bifurcatus*, *Composita* sp., all brachiopods, and *Straparolus* sp., a gastropod.

The Salem limestone which is exposed low in the valleys is composed of small fossils and small fossil fragments in an oolitic matrix. Above the Salem, the deep gray St. Louis limestone is sparingly fossiliferous, and in beds medium to massive. All beds appear as horizontal, but actually have an average dip of 25 to 35 feet per mile to the southwest. The break between the Salem and St. Louis formations is not sharp. Recurrent fossil lenses of Salem-like limestone extend up for a number of feet into the St. Louis limestone. The fossil-rich cephalopod zones are found in this transition. The cephalopod concentrations may have stood as small biohermal mounds as early St. Louis seas reworked them. As here interpreted these cephalopods are of late Salem age, but have been reworked as early St. Louis sediments.

Lithologic considerations.—The matrix of the cephalopod coquina varies from sublithographic to medium-crystalline limestone, with some oolites. There is no preferred orientation of the cephalopods in the matrix. Many of the small straight forms stand at right angles to the bedding. Crystalline calcite has replaced parts of the fossils, especially along the suture lines of the cephalopods. In the higher parts of the section some of the smaller orthoceratite forms are silicified. On the weathered limestone surfaces the silicified fossils stand out in sharp relief.

A greenish clay film covers some of the fossils and is scattered in solution seams and pockets throughout the rock. This green clay-like mineral was isolated and subjected to powder x-ray diffraction study (Laboratory, National Science Foundation, first Geologic Institute 1957).

Patterns and graphs indicate that the mineral be placed under the general term "glauconite." Electron micrographs concur with the above determination.

Fossil cephalopods.—Nautiloids dominate the fossils. The most abundant of these are gently tapering orthoceracones from 1 to 2 inches long and up to ¼ of an inch in diameter near the aperture. One fragment, if extended, would reach at least 1 foot long with a maximum diameter of 1 inch. Siphuncles are sub-central. Most of these straight forms probably belong to the genus *Mooreoceras*.

Coiled nautiloids of the order Rutoceratida are common. These average from 1 to 2 inches in diameter across the complete fossil. They are discoidal, nodose, and slightly involute. Some tests bear a single row of rounded lateral nodes on each side of the conch. Sutures are distinct and form very shallow lobes and saddles. The whorls are subelliptical in cross section and are wider than high. Several specimens show longitudinal lirae at the node lines. Siphuncles are sub-ventral. The genus compares closely to *Tylodiscoceras* (4), and to *Temnocheilus* (2).

A few nautiloids in the collection are slightly curved, rapidly expanded forms from 6 to 8 inches long with a diameter up to 3 inches near the aperture. They compare with those in the genus *Poterioceras*.

A few goniatites have been collected from the locations. They are not common. A recently collected goniatite as well as the associated nautiloid fauna is now being studied by A. K. Miller and W. M. Furnish. A similar specimen from the Greencastle area has been described (5), and named *Prolecanites americus*. These fossil goniatites vary from 1 to 3 inches in diameter measured across the whorls. They are evolute and discoidal, with sutures which form rounded saddles and linguliform lobes.

The genus *Prolecanites* is a reliable marker in the Upper Visean (Carboniferous limestone) of the British Isles and Europe, and has been used for world-wide correlation for rocks of mid-Mississippian age (1). It is hoped that as collections become more complete, that the usefulness of the fossil goniatities may be established for correlating American Mississippian rocks with the Carboniferous limestone zones of Europe.

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Age Pyramids for Indiana's Counties and Larger Cities

John Fraser Hart, Indiana University

In a discussion of migration and population change in Indiana over the decade 1940-50, it was suggested that there might be some meaningful differences in the age structures of counties having significant gains and losses by migration (1). Considerable investigation of this thesis has produced two preliminary conclusions: first, that there is no clearly discernible areal relationship between migration and age structure at the time of the 1950 Census of Population, although some such relationships might be detected by comparing migration with changes in age structure during the intercensal period; second, that areal variations in the age structure of Indiana's population at the time of the 1950 Census are worthy of study for their own inherent interest.

It is the purpose of this paper, therefore, to consider areal variations in the age structure of Indiana's population in 1950. This purpose is best served by the construction and examination of conventional age-sex pyramids (Fig. 1). Quinquennial age groups are placed on the vertical scale, with the youngest group at the base and the group 75

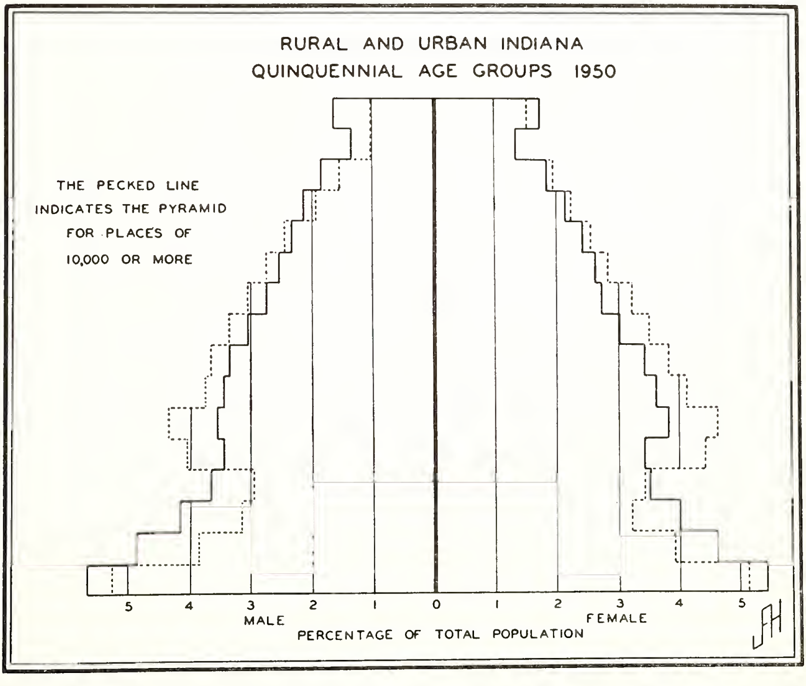

Figure 1.

and over at the apex. The length of each horizontal bar is proportional to the percentage of the total population in the specified age group, with males to the left of the center line and females to the right. The total pyramid equals one hundred percent, or unity.

The age-sex pyramid for Indiana in 1950 is strikingly similar to the pyramid for the entire country, which is indicated by broken lines where it deviates from the state pyramid (Fig. 1). Indiana has slightly greater concentrations in the age groups over 55, but the departure from the national figure is no more than two-tenths of a percentage point except in the case of males over 75. Only 8.9 percent of Indiana's population in 1950 were in the males over 55 group, as compared with 8.1 percent for the nation; comparable figures for females were 9.4 percent for Indiana and 8.7 percent for the nation.

Conversely, Indiana is slightly below the national figure in age groups 15-19 and 30-49, but again the departure is no more than two-tenths of a percentage point for any single age-sex category. In cumulative totals of males in the age groups 30-49 Indiana has 13.2 percent, as compared with 13.8 for the nation, and for females in the same groups Indiana has 13.4 percent as against 14.1 percent for the nation.

If there had been no significant changes in birth and death rates, and no significant migration, the proportion of the population in each age group would decrease gradually from the bottom to the top of the pyramid, whereas deviations from this theoretical gradual decrease indicate changes in vital rates or in migration. The declining birth rate of the 1930's is clearly evident in both state and national pyramids, but it also appears that this "bubble in the population pipeline" is more characteristic of the state's larger cities than it is of smaller towns or the open country. The shaded inner pyramid represents that portion of the state's population in places of less than 10,000 persons at the time of the 1940 Census of Population (Fig. 1).

Comparison of city and "other" population age distributions is facilitated by consideration of a second pair of age-sex pyramids (Fig. 2). The dashed line represents the total 1950 population of places having more than 10,000 persons in 1940, whereas the solid line represents the rest of the state. The pyramid for small town and rural population is relatively regular, whereas the cities burgeon in the working age groups 20-60, but fall short in the older and younger groups. This is apparently due in large measure to migration from small towns and urban areas into the cities.

In cumulative age groups on the male side of the line, the groups under 20 contain 15.4 percent of the city population but 18.5 percent of the rest; the figures for groups 20-60 are 27.8 for the cities and 24.9 for the rest; and for groups over 60 we find 5.8 percent for the cities and 7.2 percent for the rest. Similar figures are found on the female side, with 15.6 percent of the total city population in the females under 20 group, but 17.5 percent of the rest; for groups 20-60 the cities have 28.9 percent and the rest only 24.9 percent; and both cities and the rest have 6.9 percent of their total population in female age groups over 60.

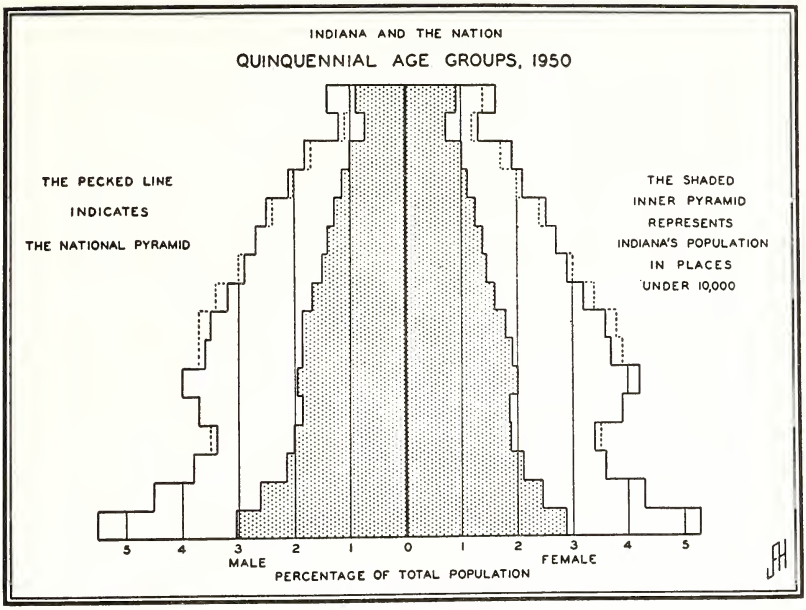

Figure 2.

Age-sex pyramids were constructed for individual Indiana cities in order to examine each city's distinctive pattern (Fig. 3). Each pyramid is centered on the location of the city, and the initial letter or letters in the name of the city appear beneath. It proved impractical to have the volume of each pyramid proportionate to the actual population of the city, but each pyramid does contain a number which indicates the 1950 population to the closest ten thousand. All data are for the year 1950, but I must remind you of the fact that the cities shown here are those which had a population of more than ten thousand in 1940, not in 1950. Whiting dropped below ten thousand persons during the intercensal decade, but this figure was exceeded by five cities not shown here—Hobart, Valparaiso, Wabash, Washington, and West Lafayette.

Colleges and universities produce the most unusual pyramids, with their large concentrations in age groups 15-30, or even 18-28, if our data were more precise. Indiana University gives Bloomington the most distinctive urban pyramid in the state. Wabash College gives Crawfordsville a similar but smaller concentration on the male side only. If Valparaiso's pyramid had been included, it would look more like Bloomington than like Crawfordsville, although the concentration on the female side would not be quite so pronounced as Bloomington's. The rest of the larger colleges and universities in Indiana are located outside the corporate limits of cities over ten thousand; some of them are evident on the next map.

Although there are broad general similarities in the pyramids of the non-college towns, there do appear to be two rather distinctly different types. Hammond and Gary offer good examples of the first

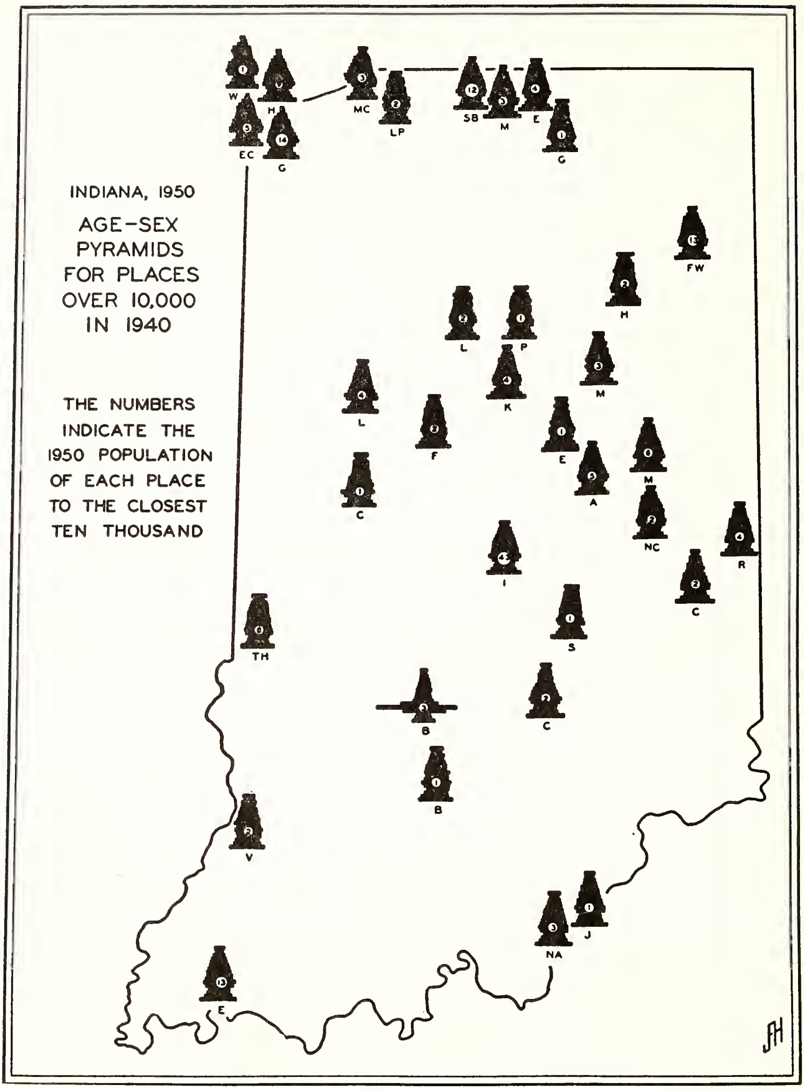

Figure 3.

type, which also characterizes Lafayette, Kokomo, Marion, Anderson, Muncie, Indianapolis, Connersville, Richmond, Columbus, Evansville, New Albany, and Jeffersonville. These pyramids have a wide base, a quite narrow "waist" in age groups 10-20, then reach a second maximum around age thirty and taper gradually to a small group 75 and over. This first type of pyramid appears to characterize vigorously growing towns; the bulge at age thirty consists in large measure of in-migrants, and the larger bulge under five is composed of their children. The large population influx has reduced the older age groups to a relatively small proportion of the total, and the total number of older persons in these cities is disproportionately low even for the state's urban areas.

The second type of urban pyramid appears to characterize slowly growing or stagnating cities. Vincennes perhaps offers the best example, but one might also examine Bedford, Terre Haute, Shelbyville, Frankfort, Elwood, Logansport, Peru, Huntington, and LaPorte. These pyramids are almost "shapeless"; the straight-sided figures of Peru and Logansport certainly do not compare favorably with the lissome curves of

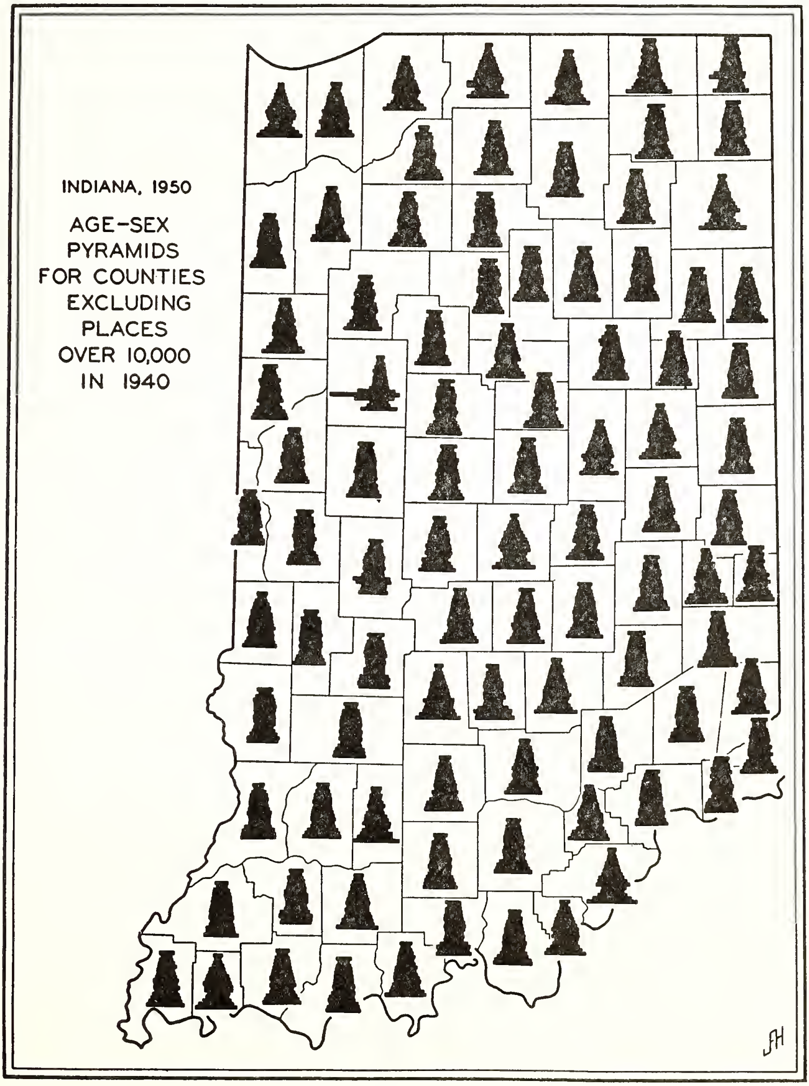
INDIANA, 1950
AGE-SEX PYRAMIDS FOR COUNTIES EXCLUDING PLACES OVER 10,000 IN 1940
JH

Figure 4.

Kokomo or Hammond. These cities would appear to be losing, rather than attracting, population in the thirty and over age groups, and they also have a larger share, both absolutely and relatively, of the state's older citizens.

The contrast between these two types of pyramids is even more pronounced in small towns and the open country, but first we should pay our respects to the exaggerated forms of Tippecanoe, St. Joseph, and Steuben Counties, or if you prefer, to Purdue, to Notre Dame, and to Tri-State College (Fig. 4). Valparaiso fails to put much of a bulge on Porter County, but DePauw makes itself known in Putnam County, and Indiana makes a small mark on Monroe. This latter bulge is in the age group 25-30, a bit old for college students, but just right for the married graduate students who live in the University's married housing project just outside the city limits. And the number of females in the 20-25 group indicates that some of their wives are a bit younger than the men they married!

On a more serious level, it is interesting to note that virtually all metropolitan counties have "growth" type pyramids: Lake (Chicago), St. Joseph (South Bend), Elkhart, Allen (Fort Wayne), Delaware (Muncie), Marion (Indianapolis), Vanderburgh (Evansville), and Clark (Louisville). Conversely, some of the more rural areas of the state are characterized by pyramids of astonishing shapelessness; look, for instance, at Jefferson, Spencer, Posey, Gibson, or Jay. Others show an obvious erosion of the working age groups, as people leave the county for jobs elsewhere. Crawford presents a good example, as do Brown, Fayette, and Pulaski. Other counties are deceptively regular; Morgan, for instance, or Lawrence, or (if we ignore students) Monroe. But this regularity is produced only by the departure of large numbers of people in the working age groups. And counties all over the state, but particularly those in the southwestern portion, have the high percentage of older persons which might almost be considered an index of rurality, at least in Indiana.

Another important concomitant of rurality in Indiana is the absence of that famous "bubble in the population pipeline." The low birth rates of the late 20's and the 30's show clearly in metropolitan counties, but there is virtually no evidence of them in the rural counties. This means, of course, that people in the working age groups have left rural areas for the cities. The move apparently begins in the 15-20 age group for females and in the 20-25 age group for males; and these are the age groups which have just been entered by the very small baby crop of the 30's.

Although the number of those entering the labor force will be smaller in the immediate future than in the immediate past, I believe that it is safe to assume that urban areas will continue to be able to compete successfully in the labor market. The farmer will manage with more machinery and less labor, but apparently the small towns and villages will be bled even whiter than in the past.

And if the small town and countryside are indeed bled white of their young people in the working (and child-bearing) age groups, another question is posed. These areas have traditionally fed the cities with people; how can the city grow if it devours the source of its own demographic nourishment? The answer lies, I suspect, in a changing areal pattern of birth rates. I sincerely hope that some geographer will soon examine the thesis that the much-talked-about "baby boom" is primarily an urban phenomenon, compounded of a fantastic increase in urban birth rates and stagnating or declining rural rates. If this thesis is indeed valid, then in future we can expect the city to feed itself, population-wise, and even produce a surplus for export to its suburbs.

I should like to conclude with a statement of some of the general conclusions derived from this examination of age structure in Indiana, with some of their ramifications:

First, there is little or no "bubble in the population pipeline" of rural areas. This fact has considerable significance for future distribution of population, for migration of population, and the areal distribution of birth rates.

Second, Indiana's older persons are somewhat more concentratel in rural areas and in small towns than in larger cities. Realization of this distribution must underly any program for dealing with our aging population.

Third, evidence of migration can be found in age-sex pyramids, but there is no distinctive type of pyramid which characterizes those areas which lost significant numbers of persons by migration in the decade 1940-50. This relationship will have to be sought by an analysis of changes in age structures over the intercensal decade.

Fourth, the paramount factor in explaining the age structure of Indiana is location relative to an urban area. Students of geographic demography will have to focus their attention on the measurement of the influence of urban areas on adjacent population groups. I suggest that two lines of investigation appear to hold significant potentialities: (a) the delimitation of "zones of demographic influence" for individual cities, and (b) the delimitation of demographic regions (similar to our physiographic, climatic, agricultural, and manufacturing regions) which presumably will have metropolitan cores.

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Revision of Mississippian-Devonian Boundary in White and Benton Counties, Indiana

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Introduction

The abandoned quarry of the White County Stone Company is located 5 miles south of the village of Wolcott, in the SW¼ SW¼ section 19, T. 26N., R. 5W., southwestern White County. The original exposures were found on a nearly flat ground moraine deposited during the Tazewell glacial substage, an unusual natural setting for bedrock outcrops. In 1929 Shrock and Malott (5) described the exposed limestone as Devonian and correlated it with the Jeffersonville limestone of southern Indiana. Their age assignment was based on sparse fossil evidence, Shrock recording the presence of the brachiopod *Spirifer divaricatus* and several corals which he did not identify in print. The 1932 Geologic Map of Indiana, however, showed the area as underlain by Mississippian rocks, and Gutschick (3) has described sponge spicules of Mississippian age collected at the quarry.

Restudy of the quarry exposures, and of samples from wells drilled in surrounding areas which were not available to Shrock and Malott at the time of their reconnaissance of the region, prove beyond doubt that a Devonian age assignment of limestone in the quarry is erroneous. The strata are Mississippian, and are a limestone facies occurring within, but near the base of, the Borden group of clastic rocks. Subsurface study of the area also indicates the need for revision of the Mississippian-Devonian boundary shown on the 1956 Geologic Map of Indiana (Scale 1:1,000,000).

Observations at White County Quarry

Shrock and Malott described the stratigraphic section at the quarry, measuring 16 feet, as consisting of alternating units of crystalline limestone and blue-gray, sandy shale. The quarry is now water-filled and abandoned, and only the upper 6 feet of the described section (Unit 6 of Shrock and Malott) is accessible. Skin-diving in the summer of 1956 indicated an actual depth of 26 feet for the quarry, but a thick layer of bottom sediment prevented any accurate determination of the character of the rocks flooring the excavation.

Megascopically, the exposed ledge consists of light tan to light gray, limonite-stained, coarsely crystalline limestone. The rock is relatively thin-bedded and fractures evenly at approximate right angles to the bedding planes. The most conspicuous feature of the fresh rock is the presence of great quantities of white crinoid fragments, some rings

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[1] The author is indebted to Dr. Robert Shaver for assistance in identification of fossils from the White County quarry, and to Mr. Seymour Greenburg for petrographic study of thin-sections.

attaining a diameter of three-quarters of an inch. Although columnal segments are common, they tend to occur in localized patches in the rock, and no fragments of calices or individual plates were observed.

Studied in thin-section, the rock consists principally of fossil-fragmental, crystalline calcite, with some unrecrystallized grains of clastic calcite. Scattered dolomite rhombs may comprise up to 10 percent of the total mass. Minor chert and shredded clay particles also are present. The limestone is more siliceous upward, and insoluble residues of the ledge constitute about 16 percent of the total sample. The siliceous material is derived, at least in part, from the remains of silicified crinoid fragments.

Identifiable megafossils are the brachiopods *Spirifer carinatus* Rowley (6), *Spirifer grimesi*, and some poorly preserved cup corals, tentatively identified as *Triplophyllites dalei* (2). *S. grimesi* has been reported from Indiana by Collett (1), but *S. carinatus* has not been reported previously in the state as far as the writer can determine. *S. carinatus* is an index fossil for the Burlington (Osage) limestone of the Mississippi Valley, whereas *S. grimesi* is known from both Burlington and Keokuk beds. The fossils, together with nearby stratigraphic data, indicate assignment of the limestone to the Osage (Mississippian) rather than the Devonian. *Spirifer divaricatus*, reported by Shrock, has not been recognized in this quarry during this study.

The lip of the quarry is at an elevation of approximately 740 feet, and therefore the limestone lies above the Rockford limestone horizon in the area as shown by subsurface data. Despite the rather detrital character of the rock, there is no definite suggestion of reef structure. Moreover, it lies several hundred feet stratigraphically lower in the Borden section than the well-known bioherms at Stobo, Monroe County, and Crawfordsville, Montgomery County. The limestone probably represents a lentil or limestone facies in the lower part of the Borden group, indicating local persistence of Rockford-type sedimentation contemporaneously with commencement of Borden clastic sedimentation in adjacent areas. Shrock and Malott recognized a similar persistence of limestone deposition above the base of the Borden silty shales in this area at exposures near Goodland and at the Alter quarry northeast of Remington, Jasper County (5).

The limestone in the quarry also lies in place at a height of 40 to 100 feet above the general level of bedrock beneath the surrounding landscape. Its preservation apparently resulted from a greater relative resistance to glacial erosion than the softer silty shales occurring nearby at the same level. The limestone must have been present as a small knob or hill in preglacial time, and has suffered little from repeated erosional attack by glacial ice.

Revision of Mississippian-Devonian Boundary

The subglacial stratigraphy of much of northwestern Indiana is poorly known because of scarcity of well data in a region where outcrops are widely scattered. Fortunately, from the district surrounding the quarry, there are available for examination many sample sets from water wells, stratigraphic tests, and exploratory wells. Such examination indicates a need for considerable revision of the Mississippian-Devonian boundary in this district as shown on the 1956 Geologic Map of Indiana. (Fig. 1). An area of more than 50 square miles in eastern Benton County and southwestern White County, shown as Devonian on the current geologic map, is actually underlain by Mississippian rocks.

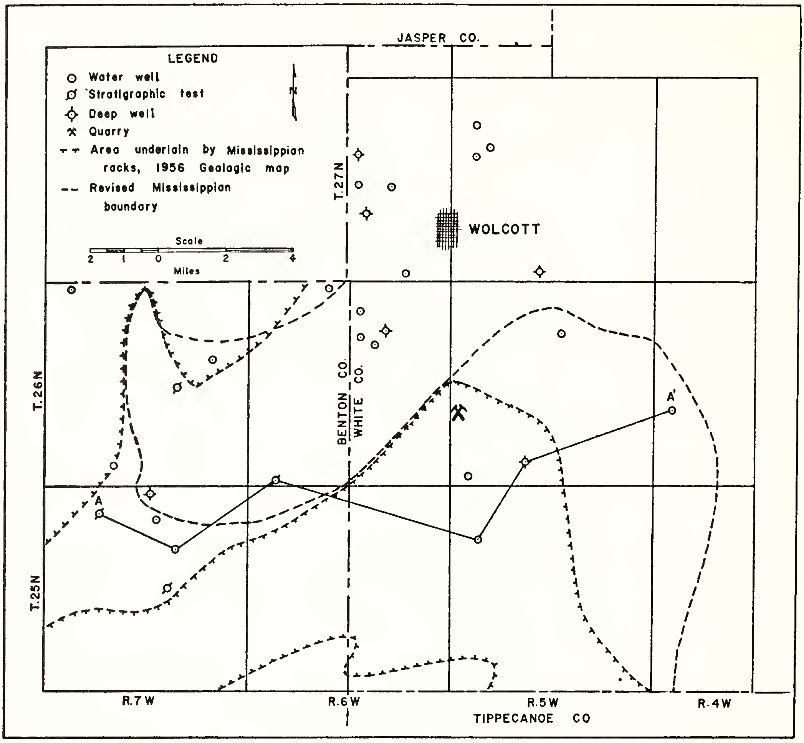

Fig. 1. Map of part of Benton and White Counties showing areal distribution of Mississippian rocks.

Most of this extended Mississippian rock area is represented either by a northern equivalent of the Rockford limestone, lying conformably on the New Albany shale, or by green, silty shales of the basal part of the Borden group of clastic rocks. The Rockford limestone averages 14 feet in thickness, with a range of 8 to 22 feet, an unusually great thickness for this formation compared with the Rockford of southern Indiana, where thickness rarely exceeds 4 feet and never more than about 12 feet (4). The samples show that the Rockford in this district is a dolomitic limestone, cherty at the top, and containing minor glauconite and possibly chlorite.

Geologic Structure

The cross-section A-A′ (Fig. 2), drawn nearly parallel to the normal regional dip, reveals some interesting structural and sedimentational-erosional irregularities. A north-south trending minor syncline, having

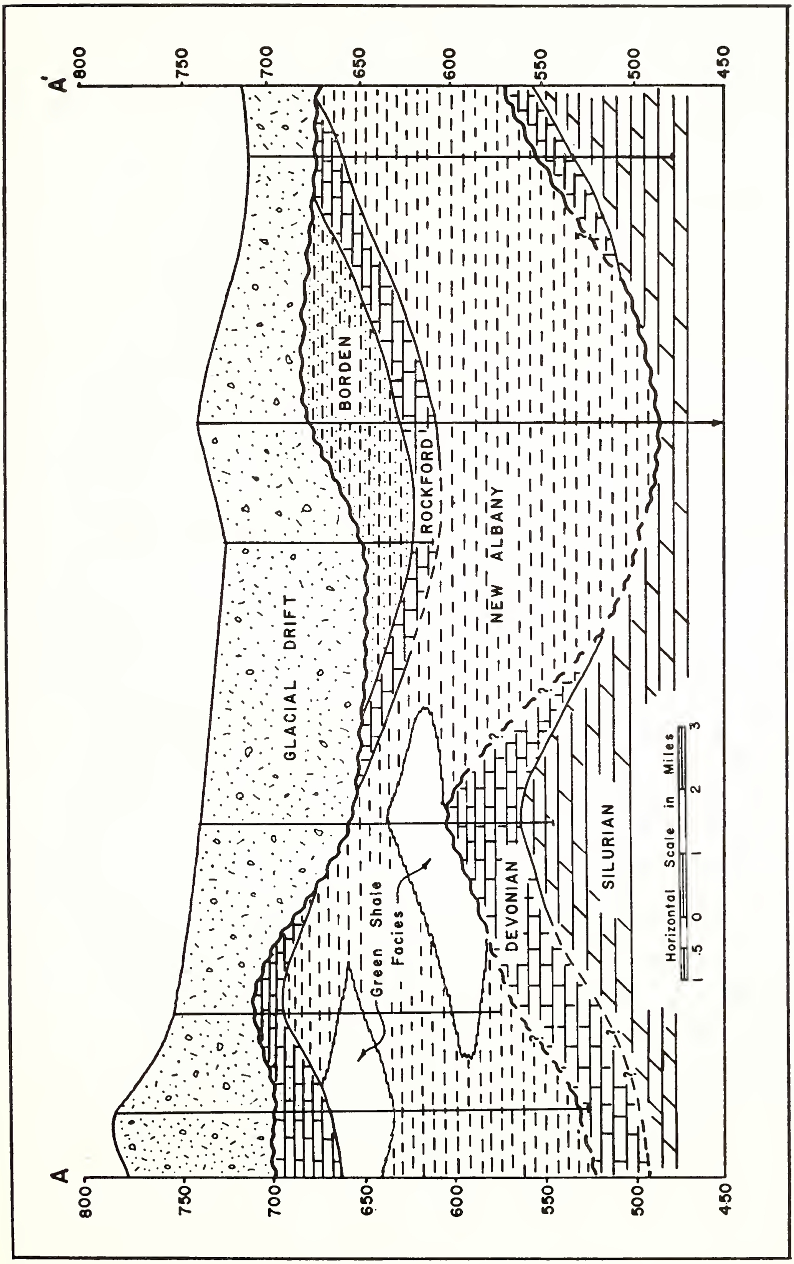

Fig. 2. Geologic cross-section across part of Benton and White Counties.

a dip reversal of about 80 feet, interrupts the normal northeastward rise of Devonian and Mississippian strata near the line between Benton and White counties. On the eastern flank of this structure, the strata again rise eastward and outcrop 5 to 7 miles beyond the point where normal regional rise would bring them to the surface. The New Albany shale thickens within this syncline, and Devonian limestone, normally 18 to 30 feet thick in the region, apparently is absent. As a result, New Albany shale rests unconformably on Silurian dolomite in southwestern White County. A New Albany-Devonian limestone unconformity in Indiana is well-known, but complete removal of Devonian limestone to create a New Albany-Silurian unconformity is not known by the writer to have been reported previously.

Summary

Carbonate rocks exposed in the White County quarry, formerly classed as Devonian, are of Middle Mississippian age. Subsurface data from eastern Benton County and southwestern White County indicate that Mississippian rocks underlie an area of 50 square miles in excess of Mississippian distribution as shown on the present geologic map of the state. The Rockford limestone is present over an extensive area in greater thickness than previously recorded in Indiana. There are evidences that more structural, erosional, and sedimentational irregularities are present in northwestern Indiana than commonly assumed. Other local studies are suggested, to assist in refining the geologic map of the state, and as a possible explorational aid in the search for industrial minerals or petroleum in a region where bedrock lithology and structure are poorly known.

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Interurban Distance in Indiana: An Evaluation of Techniques

JOHN FRASER HART and PHILIP P. COSTAS, Indiana University

Many of the phenomena studied by human geographers are discrete areal units. We might cite factories, farmsteads, villages, cities, and even dots on dot maps as examples. Although these discrete units may at times be distributed in some regular pattern, more frequently they are spread across the map in random fashion.

The measurement of areal variations in the degree of concentration of these randomly distributed discrete objects is a basic problem of human geography. Barnes and Robinson have shown that one of the best measures of the degree of concentration (or dispersion, or density) is the distance between objects (1). They find that the average distance between objects in any given area can be determined by dividing the number of objects into the actual area, finding the square root of the resulting value, and multiplying this square root by the constant 1.11. Although their study was restricted to existing administrative areas, it is obvious that the technique is equally applicable to arbitrary areal units.

This study is primarily concerned with a comparison of techniques for deriving values of interurban distance in Indiana. All towns and urbanized areas of twenty-five hundred or more persons in 1950 are plotted on the base map, as are all places of similar size in a thirty mile wide strip of contiguous states (Fig. 1). Three techniques were used to measure interurban distance.

The hexagon method is based on the work of Barnes and Robinson, but introduces arbitrary areal units in place of existing administrative units, a modification of which most geographers would approve. The use of a hexagon in preference to any other geometric form is based on Mackay's findings (2). The base map was laid out with a five mile hexagonal grid of tick marks; a transparent hexagon with twenty mile sides was centered on each tick mark, consecutively, and the number of towns falling within the hexagon recorded (Fig. 2). Four towns are within the hexagon centered at A, and five within the one centered at B. When the area of the hexagon, 1,020 square miles, is divided by the number of towns and the square root of this result multiplied by 1.11, it is found that the average interurban distance for the hexagon centered on A is 18.8 miles, and 16.9 miles for the hexagon centered on B.

The sector method is based on the assumption of a more or less regular hexagonal distribution of towns, as hypothesized by Christaller (3). Three intersecting straight lines, spaced at an angular distance of sixty degrees, were drawn on a transparent overlay, together with concentric circles at two mile intervals (Fig. 2). The point of intersection was then placed on each town and the distance recorded to the closest town in each of three or six sectors; hence "three sector" and "six sector" techniques. The three closest different sector towns to our

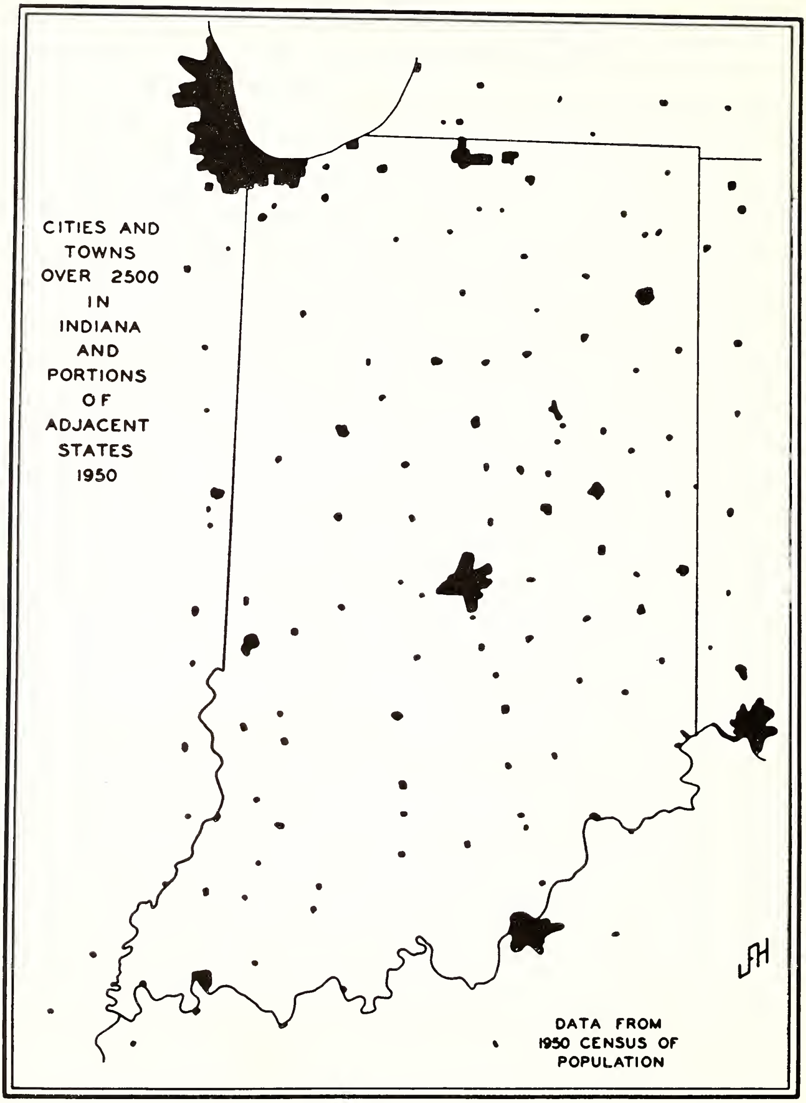
CITIES AND TOWNS OVER 2500 IN INDIANA AND PORTIONS OF ADJACENT STATES 1950
DATA FROM 1950 CENSUS OF POPULATION
JH

Figure 1.

example are 14, 17, and 17 miles, for an average distance of 16 miles by the three sector method; if the six sectors are used the average distance is 19 miles (Fig. 2). The three sector method actually measures the distance to the three closest towns which are separated by an angular distance of sixty degrees, whereas the six sector method measures the distance to the six closest towns with the same degree of angular separation.

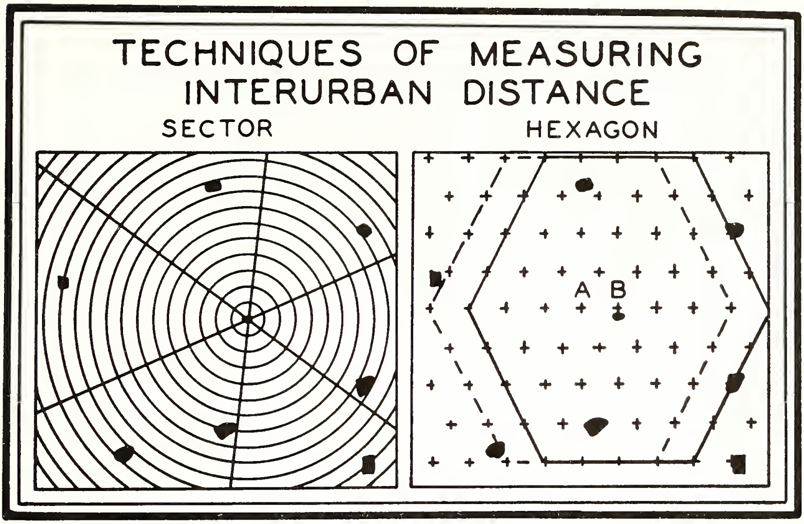

Figure 2.

The third method of measuring interurban distance is based on actual highway mileages. The distance from each town to the closest town on each state and federal highway was read from the official state highway map. The average interurban distance was computed, as in the sector method, by totalling these distances and deriving an arithmetic mean. Each of these three measures was used to determine "spot heights" for construction of conventional isopleth maps of interurban distance.

The most important fact made evident by comparing the four maps produced by these three methods is the discovery that each method produces a map showing the same general pattern of interurban distance, although there are minor variations in detail (Fig. 3). Distances determined by the three sector method, for instance, are necessarily lower than those determined by the six sector method, because the average distance to the three closest towns will have to be no more than equal to—and commonly is considerably lower than—the average distance to the six closest. It should be added that we found it impractical to attempt comparability of specific critical mileage values separating distance classes as measured by the different methods.

We should also emphasize the fact that our primary concern in this study is interurban distance, and not urbanization. The size and areal extent of towns are disregarded when all are weighted at unity, when Delphi and Brookville are made equals of Indianapolis and Gary. These techniques obviously are most significant in predominantly rural areas of discrete small towns, where interurban distance is also most significant, and least significant in metropolitan areas, where the concept of interurban distance is less meaningful.

Interurban distance, for instance, is greater around Indianapolis than in some other parts of the state (Fig. 3). All of these maps

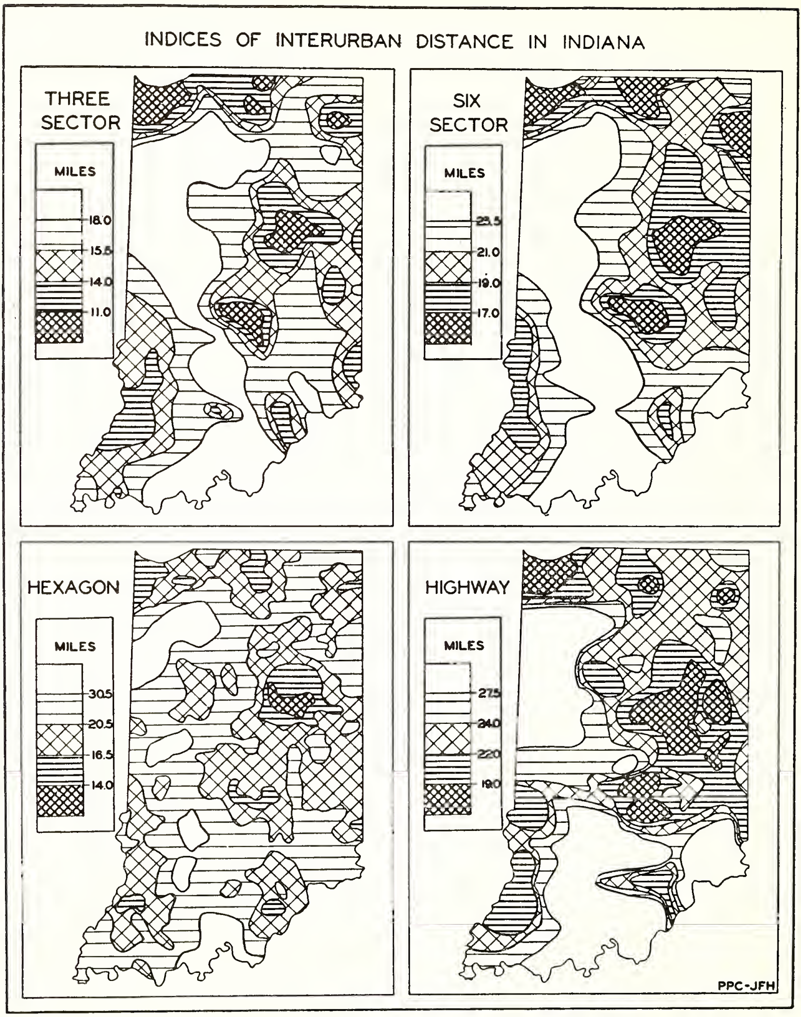

Figure 3.

show a minimum interurban distance in the east central part of Indiana, between Muncie and Marion, with another area of minimal distance south and west of Indianapolis. Interurban distances are also low in the northwestern corner of the state, near Chicago; in the South Bend-Elkhart area; north of Fort Wayne, in DeKalb County; east of Richmond, in Wayne County; in the Scottsburg Lowland, north of Louisville; and in the coal mining areas of southwestern Indiana. Conversely, there are two extensive areas of maximum interurban distance, one in the southeastern corner of the state and the other stretching in a broad belt to the west of a line from Chicago to Louisville.

The similarities of overall pattern on these four maps leads us to the conclusion that the best of the four techniques is the one which is most economical of time. This conclusion hands the palm to the three sector method of measuring interurban distance, although we would like to suggest that further experimentation with the hexagon method, both by increasing the grid spacing interval and the size of the measuring hexagon, might considerably enhance its speed without impairing the results obtained.

In particular, the hexagon method would appear to be of considerable utility as the number of items in the distribution increased, as, for instance, in converting a dot map to a density map, in preparing a map of interfarmstead distance for areas larger than county size, or in mapping interurban distance for the nation. These suggested applications indicate, of course, the fact that the techniques described in this study are applicable to any random distribution of discrete objects.

Before concluding, we cannot forebear calling your attention to striking areal co-variations between interurban distance and the importance of migration as an element in rural population change in Indiana in the decade 1940-50 (4). Significant in-migration corresponds with minimal interurban distance in the northwestern corner of the state, from Chicago to Elkhart; in the east central part of the state; and in the general vicinities of Fort Wayne and of Louisville (Fig. 4).

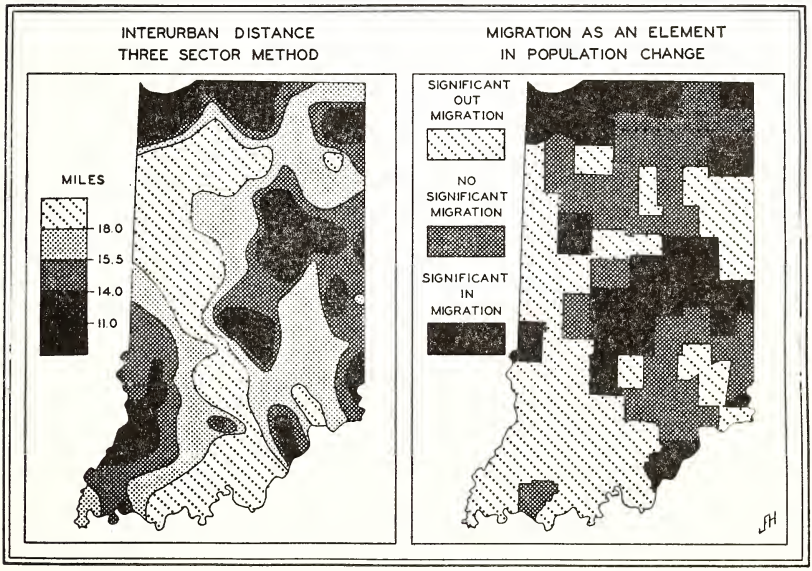

Figure 4.

Even more marked is the correspondence between areas of high interurban distance and significant out-migration. This is especially true of the area west of a line from Chicago to Louisville, but the same pattern holds in the southeastern part of the state as well. Furthermore, interurban distances are somewhat higher than the state norm even in those counties which held their own migration-wise. But there are two exceptions; the areas of significant out-migration between Fort Wayne and Muncie and between Terre Haute and Vincennes have comparatively low interurban distances.

Once the relationship has been discovered by visual comparison of these maps, its mechanics are obvious: those people who live far from the nearest town are more likely to migrate than those who live close to one. But let us remind you of the man who made his million by placing the obvious bit of rubber on the end of the lead pencil. This relationship had not occurred to us before it was suggested by our comparison of the two maps, true enough, but neither had it been suggested in discussion of the senior author's paper at this meeting last year, and inasfar as we can ascertain it nowhere appears in print.

We should like to conclude, therefore, with the suggestion that preparation of interurban distance maps for other areas, and eventually for the entire country, might well call attention to other relationships which presently are not even suspected.

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Transgressions and Regressions of Early Allegheny (Pennsylvanian) Seas in Indiana

HAYDN H. MURRAY,[1] Indiana University

Introduction

The cyclical nature of Pennsylvanian sediments was recognized by many early workers including Udden (5) and Stout (4). Moore (2), Weller (12, 13), Wanless (6, 7), and Cline (1) described Pennsylvanian successions in central and east-central United States. Recently, Wanless and Patterson (9) have described cyclic sedimentation in the marine Pennsylvanian of southwestern United States.

Many correlations have been based on groups of repetitive beds sometimes called cyclothems. Wanless and Weller (11) defined a cyclothem as a series of beds deposited during a single sedimentary cycle of the type present in the Pennsylvanian period. In stratigraphic nomenclature a cyclothem ranks as a formation. Wanless (7) correlated many of the Pennsylvanian rocks on the basis of cyclothems. Pennsylvanian correlations are always difficult because the character of the sediments changes rapidly. For example, coals thicken and thin in relatively small areas, limestones vary in lithology and thickness and are often cut out by unconformities. Facies changes are common in the Pennsylvanian sedimentary rocks.

Regional Cyclothemic Patterns

Weller (12) described a cyclothem of ten members, occurring in western Illinois in the following order:

10. Gray shale with clay ironstone bands or nodules.
9. Marine fossiliferous limestone and calcareous shale.
8. Black, slaty shale, frequently with large black spheroidal limestone concretions containing marine fossils.
7. Marine limestone or shale.
6. Gray, non-calcareous shale without marine fossils and commonly with plant fossils.
5. Coal.
4. Underclay, non-laminated, with at least the upper part generally non-calcareous.
3. "Fresh-water" limestone, generally nodular, discontinuous, and unfossilferous.
2. Sandy shale.
1. Sandstone, in some instances conglomeratic and locally resting on erosional surfaces.

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The members 1 (sandstone), or 2 (sandy shale), 4 (underclay), 5 (coal), 8 (black shale), 9 (limestone) and 10 (gray shale) are the most persistent units and, therefore, the most commonly encountered in Indiana. Wanless (8) stated that studies in other parts of the United States have shown that the succession described by Weller is not characteristic of the Pennsylvanian throughout any large area. Individual members thin out or change in lithology so that over widely separated areas the sedimentary rocks will be cyclic in nature but the lithology may differ. In the southwestern portion of the United States the Pennsylvanian rocks are dominantly marine. In Arizona and New Mexico, Pennsylvanian rocks are almost wholly marine, in Kansas they are about 40 to 75 percent marine, in Illinois and Indiana 10 to 25 percent marine, and in West Virginia they may range from less than 1 percent to nearly 5 percent marine (8).

Wanless (8) listed four broad factors which influence the depositional pattern in a locality.

1. Relief and lithology (the proximity, extent, relief, and lithologic make-up of the nearby lands yielding detrital particles).
2. Depositional environment (whether the locality across which the strand line migrated was generally above or below sea level).
3. Rate of downwarping of the depositional basin.
4. Climate (the climate in the depositional basin, in the area of derivation of sedimentary particles and in the area through which these particles were transported).

The cause for the repetitive cycles present in the Pennsylvanian rocks has been explained in numerous ways. Stout (4) attributed the cycle to intermittent subsidence. Weller (12) believed the cycle resulted from diastrophism involving both uplift and subsidence. Wanless and Shepard (10) proposed that the depositional basins were subsiding intermittently in conjunction with eustatic shifts in sea level caused by alternate growth and waning of Gondwana glaciation.

Cyclothemic Patterns in Western Indiana

In work completed on the Pennsylvanian underclays and shales along the eastern edge of the Eastern Interior basin, some anomalies in the succession of marine and non-marine beds have been noted. These anomalies can best be explained by transgression and regression of the Pennsylvanian seas across the area along the eastern edge of this basin. On Figure 1 a typical marine transgression is exemplified by the members which include the "Minshall" coal (Rock Island Coal of Western Illinois (7)).

The arenaceous shale was considered by Weller to be non-marine, i.e., deposited in relatively fresh water. Some workers consider underclay to be the old soil on which the vegetation grew to form the coal. Coal is characteristic of a swamp or paludal environment. The marine invasion started with the deposition of the black fissile shale which is

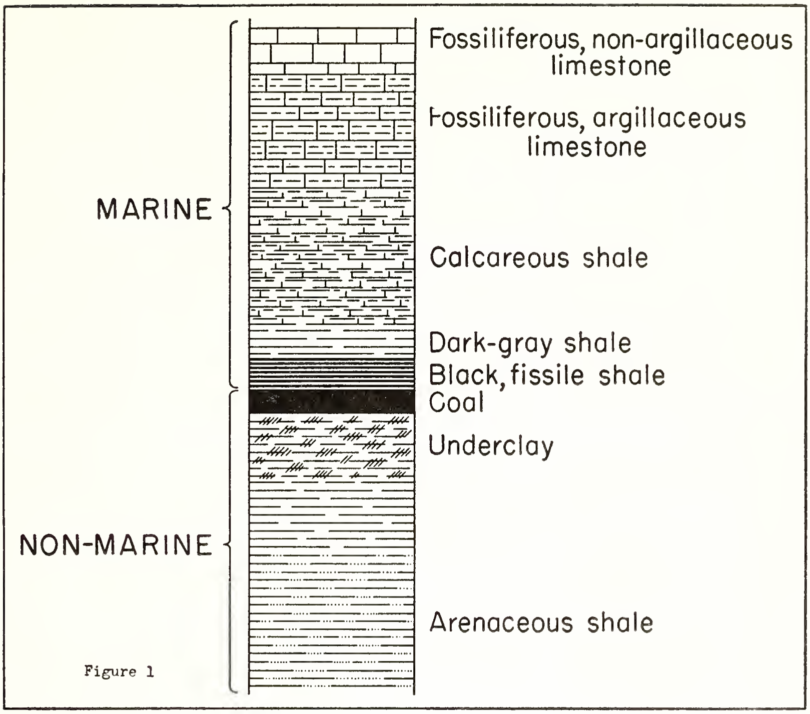

Figure 1. Cyclothem in Western Indiana which includes the Minshall coal.

characteristic of a restricted, brackish water environment. This black shale grades upward into a marine fossiliferous shale and limestone which represents marine conditions with open circulation. The fossiliferous limestone appears clastic in many places which presumably indicates that it was deposited above wave base. Such a non-marine through marine sequence is evident in the Linton formation (14) in the members underlying Coal IIIa and in the Petersburg formation including Coal IVa and Coal V.

If sea level were eustatically shifted a regressive phase of deposition should be evident in some of the Pennsylvanian rocks. This regressive phase should logically have a sequence of members which is partly reversed from those shown for the typical marine transgression. In a regressive sequence the marine portion would be below the coal and the non-marine portion above it. This sequence of beds might be generalized as shown on Figure 2.

The cyclic repetitions of members instead of being non-marine-coal-marine-non-marine-coal-marine would be non-marine-coal-marine-coal-non-marine-coal, etc. (Figure 3). The sequence would be marine between two coals and non-marine between the next two if the transgressions and regressions of the sea were cyclic.

Many of the numbered coals of Indiana have rider coals above them, which are generally relatively thin, and many of the rider coals are

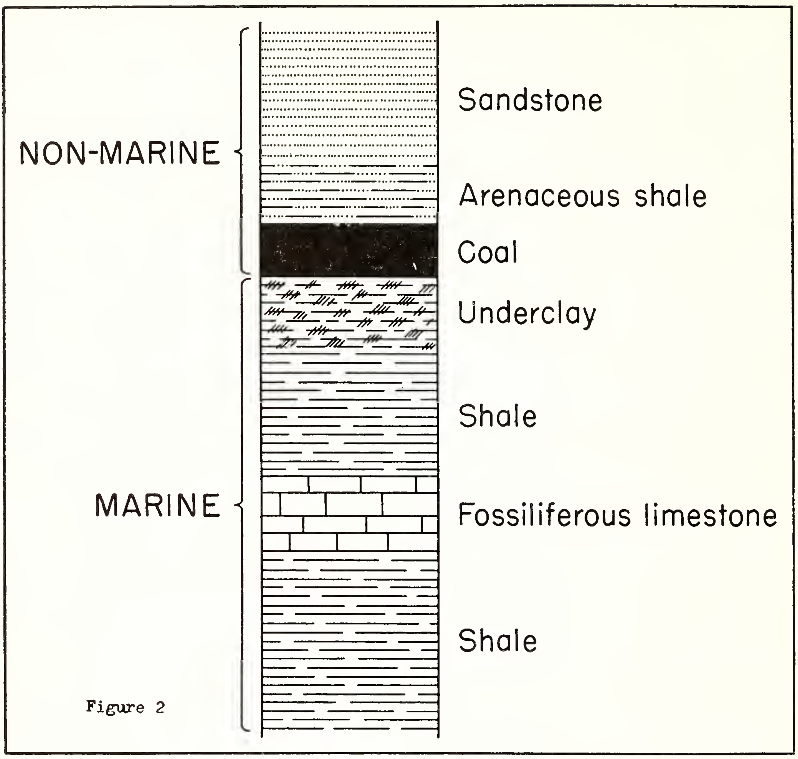

Figure 2. Generalized sequence showing reversal of normal cyclothem.

overlain by gray shale. Some of the rider coals without the normal black fissile shale overlying them may represent the regressive phase of deposition. Other rider coals have black fissile shale and marine limestone above them and represent the marine transgressive phase of the cyclothem. An example of a sequence in Indiana which includes both the transgressive and regressive phases is in the Staunton, Linton, and Petersburg formations (all Alleghenian in age) (Figure 4).

Wilson pointed out (15) that marine limestones are found below the underclay in some cyclothems. The Universal limestone underlies Coal VII and a thin limestone underlies a rider coal to V, both coals of the Dugger formation in Indiana. The presence of these underclay limestones, as Wilson has called them, can best be explained in many instances by regressive phases of deposition. Further analyses of underclay formation, mineralogy and geochemistry of shales, and spores in coals will have to be made to substantiate fully the idea of transgressive and regressive deposition. A study of the underclays and shales is in progress in the author's laboratory. This study has revealed that the illite content of the shales in the marine sequence is generally higher

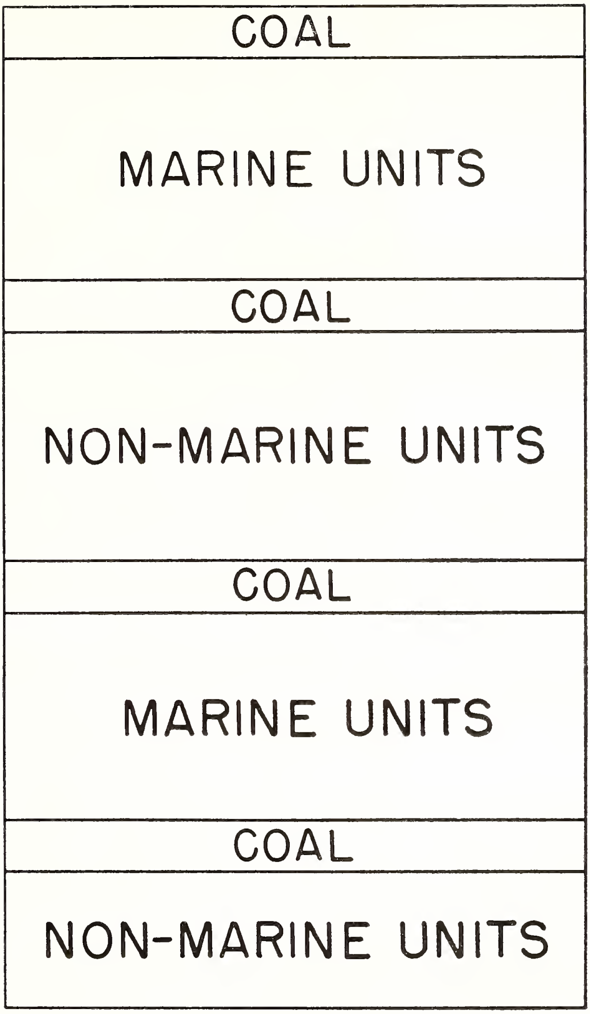

Figure 3

Figure 3. Idealized sequence indicating alternate transgressions and regrssions.

than it is in the non-marine sequence. Murray (3) and others have pointed out that illite is the dominant clay mineral in most marine shales.

In conclusion, it must be emphasized that this transgressive and regressive sequence of deposition is postulated only in a limited area along the eastern edge of the Eastern Interior basin, but other geologists should look for similar evidence in areas where Pennsylvanian sedimentation occurred on the unstable intracratonic shelf areas.

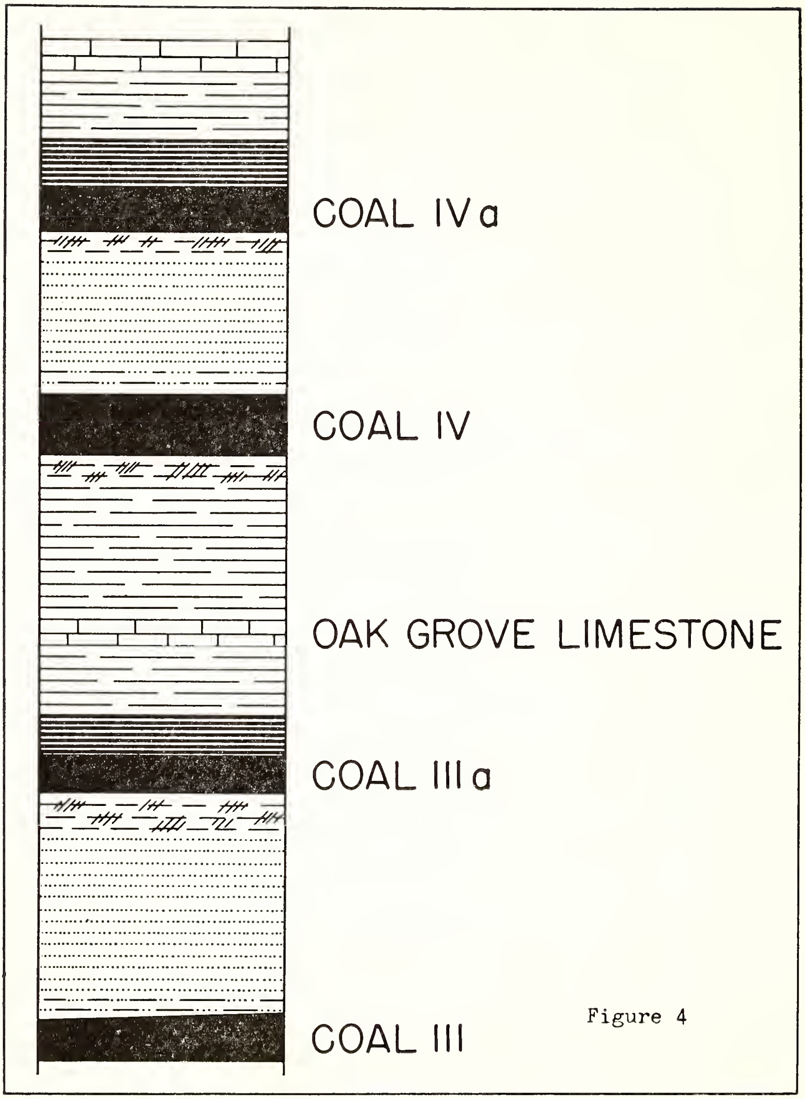

Figure 4. Cyclothems in western Indiana best explained by alternate

Summary

Recent lithologic investigations in the lower part of the Allegheny series in western Indiana indicate that the sediments were deposited in transgressive and regressive seas that resulted in an ascending sequence of nonmarine beds—coal (developed in front of the transgressive sea)—marine beds—coal (developed behind the regressive sea)—nonmarine beds, etc. This sequence suggests that deposition occurred under conditions of marine transgressions and regressions along the eastern fringe of the Eastern Interior basin in early Alleghany time.

Transgressive-regressive conditions prevailed in restricted areas of subdued relief that were intermittently occupied by shallow, epicontinental seas. Such conditions, briefly maintaining in early Allegheny time in western Indiana, developed the following generalized stratigraphic sequence: (1) Arenaceous shale and/or sandstone, (2) underclay developed on non-marine material, (3) coal, (4) black fissile shale, (5) fossiliferous shale, (6) fossiliferous limestone, (7) argillaceous shale, (8) thin nodular limestone, (9) underclay developed on marine material, (10) coal, and (11) arenaceous shale and/or sandstone, lithologically similar to (1).

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The Misleading Antithesis of Penckian and Davisian Concepts of Slope Retreat in Waning Development

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In the last thirty years or so, geomorphologists have shown intermittent but lively interest in the problem of slope development. A segment of this large and difficult problem has taken the form of a controversy, sometimes phrased rather loosely as follows: under the condition of a stable base of erosion, does the valley slope retreat parallel to itself or does its inclination decline with age? The former position is attributed to W. Penck and the latter to W. M. Davis. The presumed contrast in slope forms resulting from these concepts is illustrated by Davis in a simple diagram in his paper on "Piedmont Benchlands and the Primärrümpfe" (1). This diagram (Fig. 1) has been reproduced, and served as a basis for discussion, at least three times. It appears, for example, in the symposium on W. Penck held by the Association of American Geographers in 1940 (2), in C. A. Cotton's popular textbook "Landscape" (3), and, more recently, in L. C. King's paper on the "Canons of Landscape Evolution" (4).

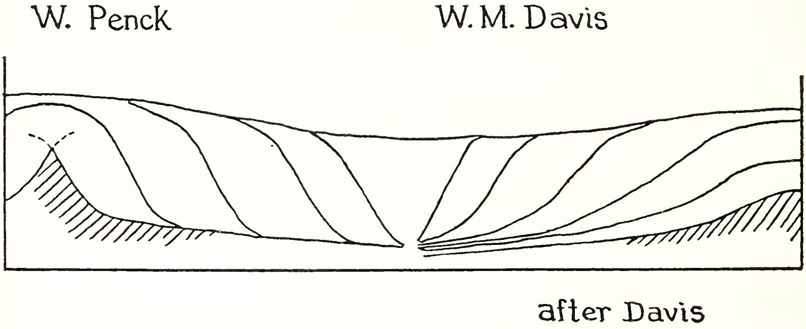

Figure 1.

Davis's diagram served to emphasize the opposition between Davisian and Penckian concepts of slope retreat. His simplified presentation tends to mislead because it neglects an important implication in Penck's analysis; namely, during waning development (absteigende Entwicklung), only the cliff or rock wall (Steilwand or Felswand) of the valley slope retreats parallel to itself. The valley slope as a whole becomes concave and its gradient declines in a way similar to Davis's own conception (5). The cliff (A, B, or A_5, C_5 in Fig. 2) is assumed at the beginning of Penck's deductive treatment in order to allow graphic presentation. If one starts the analysis with a valley slope of gentler inclination than the cliff, as, for instance, the slope B, D_n, C_n in Fig. 2, then the subsequent stages of slope flattening become almost identical

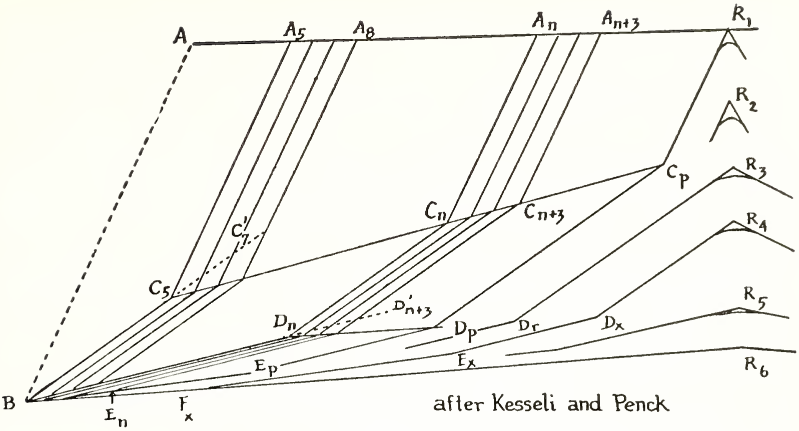

Figure 2.

with those conceived by Davis. The slope B, D_n, C_n is a smooth, concave curve. The break of slope in the valley side occurs only at the junction between the cliff (Steilwand) and the uppermost segment of the denudational slope (Haldenhang), along the line C_5, C_p where there is a change in transportational process from free fall to creep, sliding and rainwash. The denudational slope below the cliff is a smooth curve, since a. the inclination of each segment of the denudational slope is determined by the mobile size of the debris, which shows a smooth gradation; b. as soon as the Haldenhang appears beneath the receding cliff, processes of denudation would operate to produce a gentler subjacent slope segment. In Fig. 2, on the other hand, a slope segment of gentler inclination than the Haldenhang is assumed to appear only after five units of time have elapsed. The Haldenhang is thus drawn as a straight line that meets lower and gentler slope segments, also represented as straight lines, at distinct breaks. This departure from logical rigor is inherent in the graphic method of analyzing continuous and simultaneous processes.

Davis's diagram further stresses the contrast between the Penckian and Davisian concepts of slope retreat by his presentation of their views on the development of the crests of the interfluves. According to Davis, the crests of the interfluves become broadly convex in the late stages of the cycle (Fig. 1). Penck, on the other hand, argued for the prevalence of concave slopes in waning development. But he did not conclude that the residual hill should be a sharp peak as Davis depicted it in his diagram. Penck recognized and attempted to explain the rounding of hill-tops independent of his premise on rates of uplift (6). Hence the difference in viewpoint between Penck and Davis regarding the curvature of interfluves in waning development narrows down to a difference in the length of the convex arcs when the valley slopes are seen in profile. Recent observations by King and Sharp suggest that Davis has exaggerated the length of the convex arc in a region of waning development (7).

The convolute prose of Penck's treatise, "Morphological Analysis of Land Forms," is well known. His arguments are not always complete and are invalid in places. Some of Penck's statements regarding slope development have been expanded and lucidly re-stated by J. E. Kesseli (8). A careful reading of Penck's works shows that his concept of slope retreat in waning development differs less from the view expressed by Davis than is sometimes supposed. Thus in a paper on "The Piedmont Benches of the Southern Black Forest," published posthumously in 1925, Penck (9) has a simple sketch (Fig. 3) that illustrates the gradual flattening of a valley slope in the true Davisian manner. Davis, on his part, has modified his stand on slope flattening as a universal principle. He realized that the boulder-clad cliff or Felswand is a common slope element in arid regions, and admitted that such a cliff may undergo parallel retreat, in distinction to the basal slope which flattens (10).

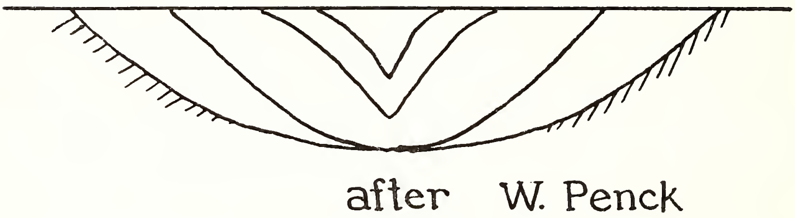

Fig. 3

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Reclamation Of Strip-Mined Lands in Vigo County, Indiana

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Geographical and geological conditions have favored strip coal mining in Southwestern Indiana. The coal seams commonly lie below undulating to rolling plains, which permit the use of large machinery and aid in the installation of preparation plants and transportation routes at optimum locations. Several nearly horizontal seams of coal lie at relatively shallow depths and generally vary from three to eight feet in thickness. Most of the overburden consists of relatively soft, easy-to-handle clays, limestones, and shales. These conditions have enabled strip mining companies to produce most of Indiana's coal in recent years.

Within Southwestern Indiana about 70,000 acres of land have been strip mined for coal (Fig. 1). The greatest area of strip mining is in Pike and Warrick Counties where more than 25,000 acres of land have been stripped. Approximately 4,500 acres of land have been strip mined for coal in Vigo County, and 900 additional acres have been covered with spoil. Most of the strip mining in Vigo County has taken place around the Riley-Blackhawk area in Riley and Pierson Townships. Large reserves of Indiana No. V coal are in this area. The overburden averages about 65 feet in depth but varies from 40 to 90 feet, and is generally relatively easy to handle.[1] It commonly consists of about 10 feet of hard shale on top of the coal, followed by 6 feet of hard limestone, 7 feet of shale, 3 feet of limestone, 34 feet of gravelly clay, and 5 feet of clay, silt, and soil (Fig. 2).

Most of the remainder of the strip mining in Vigo County has taken place south of Seelyville in Lost Creek Township, southeast of Pimento in Linton Township, and in the northeastern corner of the county around Fontanet in Nevins Township (Fig. 3).

About five per cent of the agricultural land of the county, which is medium grade agricultural land, has been strip mined. Since most of the stripped area was under tillage prior to stripping, the physical landscapes have been markedly altered. Strip-mining operations generally take place throughout several contiguous sections, and so strip mining leaves the surface of large contiguous areas worked in a series of rough ridges and valleys (Fig. 4). The steep slopes of the typical saw-tooth profile of stripped areas causes the loose materials on the ridges to erode rapidly. The severity of erosion varies with the physical composition of the spoil material, the degree of slope, and the density and character of the vegetation. But the general rapid rate of eroding the spoil banks constitutes a principal reclamation problem.

Another detrimental effect of strip mining, in addition to erosion and removing the land from agricultural tillage, is that of unsightliness. The spoil banks of newly overturned earth give a desolate appearance to the landscape. The spoil banks, if left without vegetation, stand as an unsightly blot on the landscape. Natural vegetation will come

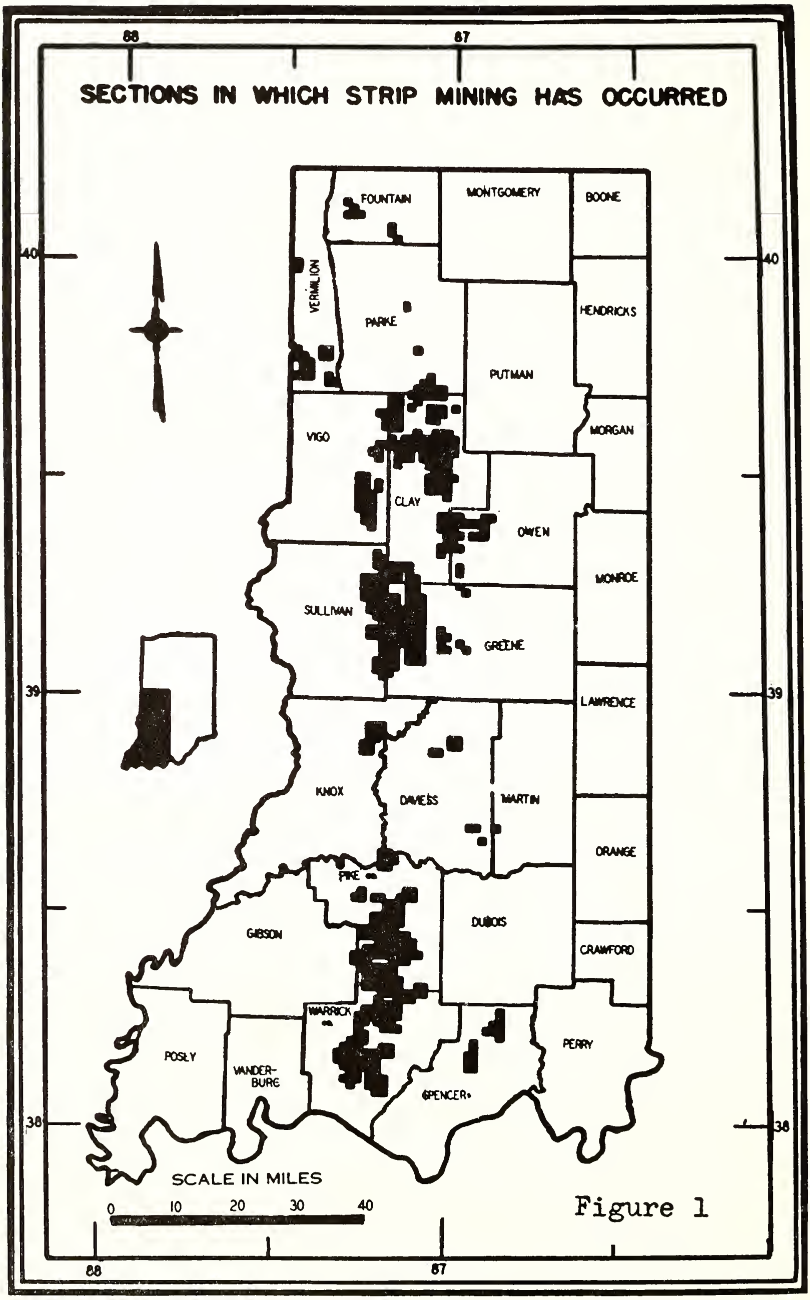

SECTIONS IN WHICH STRIP MINING HAS OCCURRED
88
87
40
39
38
FOUNTAIN
MONTGOMERY
BOONE
VERMILLION
PARKE
HENDRICKS
PUTMAN
MORGAN
VIGO
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
KNOX
DAVIESS
MARTIN
ORANGE
PIKE
DUBOIS
GIBSON
CRAWFORD
WARRICK
PERRY
POSLY
VANDER-
BURG
SPENCER
SCALE IN MILES
0
10
20
30
40

Figure 1

up in some areas, but most will remain barren for some time. Natural reforestation is very slow on most spoil banks. It normally produces an inadequate, or barely adequate, tree cover for the first couple of decades. Not only is natural reforestation very slow, but the trees or grasses which grow on spoil banks are practically all of the less

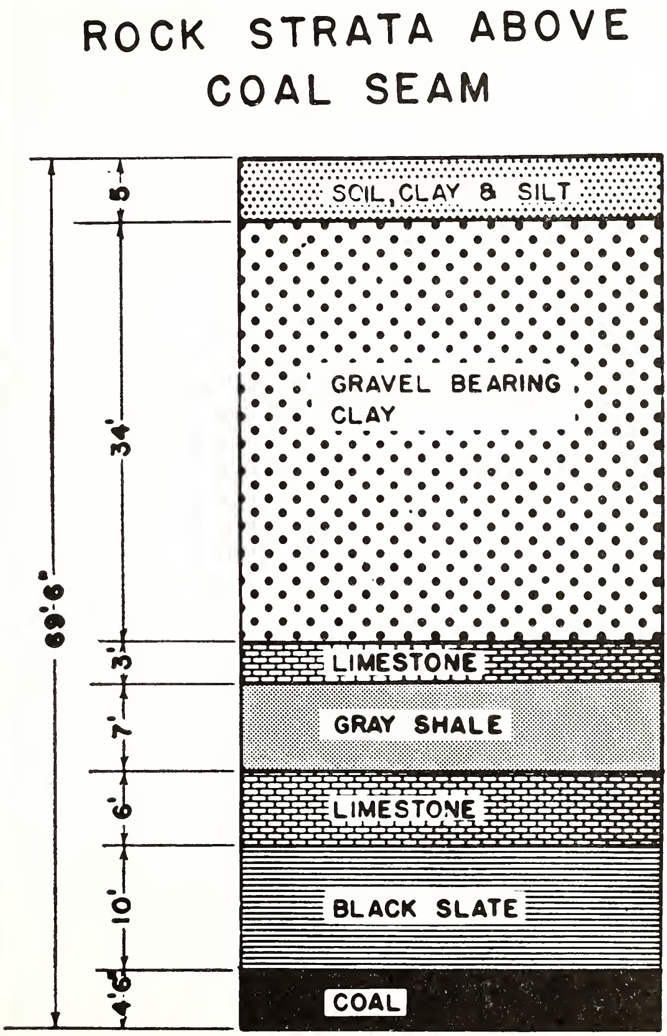
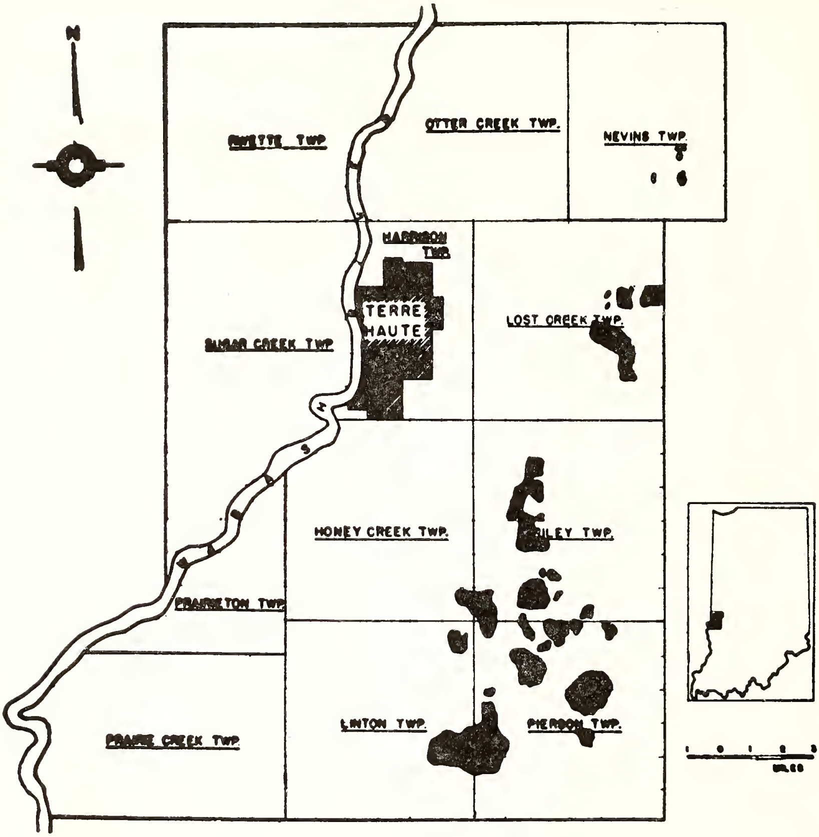


Figure 2



LAND WHICH HAS BEEN STRIP MINED

Figure 3

valuable species. In cases where a heavy volunteer stand of timber does develop on strip-mined land, the trees are generally short-boled, limby, and contain few high-grade products. Except during periods of unusually heavy demand, these trees probably could not be marketed as saw timber.[2]

In addition to the slow growth, undesirable quality and poor species, the natural tree stand has the further handicap of being poorly distributed over the spoil banks. The most valuable tree species are normally confined to the outer portions of the stripped areas. Saw-timber and pole trees generally occur only in scatter clumps. Most of the openings between trees are covered with weeds, grasses, briars and shrubs. The better timber species find it difficult to invade this type of ground cover.

The most important function served by the natural vegetation, since the trees are of little or no commercial value, is in providing a site for more valuable species. In this respect, the natural vegetation provides a good index of the ability of the spoil banks to support vegetation. However, the spoil banks have been wasted of their potential production

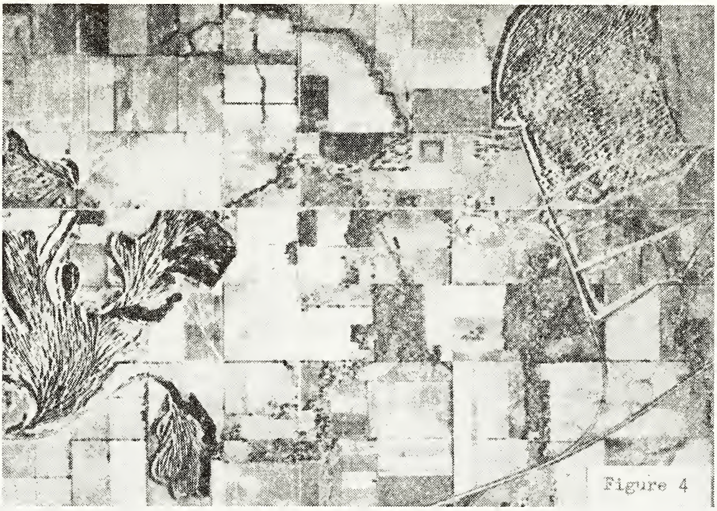


Figure 4

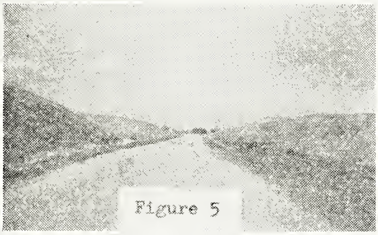


Figure 5

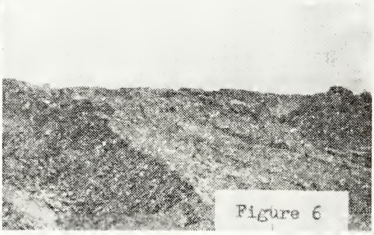


Figure 6

Figure 7

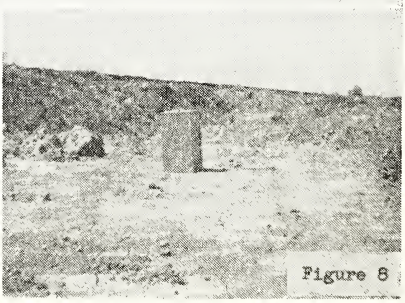


Figure 8

during this time. While reliance on nature to provide a good tree stand requires the patience of Job, spoil banks planted in trees can produce marketable trees within a reasonable period of time.

During the 1930's under the impetus of the Indiana Coal Producers Association, a few hundred acres of spoil banks were voluntarily planted in trees in Vigo County. Since 1941, when the State Legislature first passed a law drafted by the State, the Farm Bureau, and the coal industry), all the strip-coal operators are required to revegetate all the acreage disturbed. In addition, the present Indiana law states that "the operator shall work any unsightly ridges remaining in the operation by striking off the same to a width of at least 8 feet at the top. Any unsightly, isolated peaks shall be graded at the top to a minimum of 15 feet. Grading shall be carried on to reduce unsightly peaks and ridges to a rolling topography immediately adjacent to public highways."[3] The act of 1951 further states that "On all areas seeded to pasture, said operators shall strike off peaks and fill valleys in such a manner that the area can be transversed with farm machinery" (Figs. 5 and 6).

Grading of Spoil Banks

Whether or not spoil banks should be graded is a controversial issue. A casual consideration of the question may lead observers to quickly conclude that grading would reclaim the land and fit it for profitable crop land. On the other hand, strip-mining companies are quick to point out a high cost of grading spoil banks and they also add that the absence of topsoil still results in low productivity and reduced land values.

Most strip-mine operators oppose grading of spoil banks. They generally state that grading causes excessive compaction which, in turn, causes poor aeration and low percolation rates. These adverse conditions are usually said to be due to the weight of grading machinery and from the weight of the materials which were located above the newly formed surface before grading.

An analysis of the compaction of spoil material by the writer indicated the contrary. Numerous compaction tests showed that graded spoil banks have a lower compaction than surrounding unmined lands (Figs. 7 and 8). The average of all graded spoil banks tested was 86.4 per cent as dense as natural soil density. This is true despite the fact that many density tests were taken in places which had been unusually compacted by numerous trips of the tractor-crawler tracks. Thus, it appears to the writer that graded spoil banks are loose and friable enough to support any vegetation that grows on adjacent unmined land.

Variations in compaction ranged from 68.6 to 92.5 per cent as dense as unmined land. The amount of compaction apparently depended mainly upon the length of time between the strip mining and grading processes, the method of performing the grading process, the texture of the spoil, and the moisture content at the time of grading. The least compact area had a short interval between strip mining and grading, had the dragline scatter the material, and graded coarse-textured spoil with a crawler tractor when it was dry.

No doubt, grading is generally desirable. It makes the strip-mined lands more accessible, and it reduces the unsightliness. Grading especially improves the appearance of the landscape during the first years after strip mining and during the winter when the foliage is absent. It makes spoil banks accessible for pastures and is also essential for efficient tree plantings and logging operations.

The amount of grading done is usually determined by how rugged or unsightly the mined area appears and the future land use of the spoil banks. For example, if the spoil banks are adjacent to a public road, they are often graded down to a rolling topography. The further the spoil banks are from the road, the less the amount of grading normally done. Likewise, the amount of grading done also depends upon the general cross section of the spoil banks. For example, the higher and more peaked the spoil, the more grading required. Finally, the ultimate use of the stripped land is a deciding factor in the amount of grading required.

Reforesting Spoil Banks

Tree planting has been the most popular method of revegetating spoil banks. Original planting costs are usually low, the planted trees grow rapidly, hide spoil banks quickly, and provide an attractive cover. In a few years, plantings reduce bank erosion and provide a good setting for recreational areas. Finally, these planted spoil banks grow forest crops with several plantings on strip-mined lands growing more rapidly than the same species planted on unmined lands.

Originally many different species were planted. It was not known which trees would survive, which would grow fastest, how close to plant them, when to plant them, and how to plant them. Past failures and successes, together with knowledge gained from research, now give us suggestions for successful tree plantings.

Some of the earliest plantings have reached the point where they can produce such forest products as fence posts, mine props, poles, and Christmas trees in Vigo County. The earliest plantings of deciduous species were limited mainly to pure stands of black locust. Many were so badly riddled with black locust borers that the tree is no longer planted in pure plantations. However, when locust trees are mixed with other hardwoods, they seem to have found their rightful place. Among the trees with which locust has grown well in Vigo County, Indiana, are red oak, black walnut, and tuliptree (Fig. 9).

Some experiments have been conducted on direct seeding instead of planting trees. They have generally shown poor and erratic results which indicates that planting of tree seedlings is more practical for general use than direct seeding. Insects, pests, diseases, and hot, dry weather in early summer all are more likely to cause failures in direct seeding than in planting trees. Planting is more likely to give satisfactory results over a number of years which include both good and poor planting seasons.[4]

Revegetating with Grasses

Grasses also yield good returns in certain spoil banks, but the chances of failure are greater than by planting trees. Mixtures of legumes and grasses are generally considered best because of better erosion control, thicker growths and better seasonal distribution. After

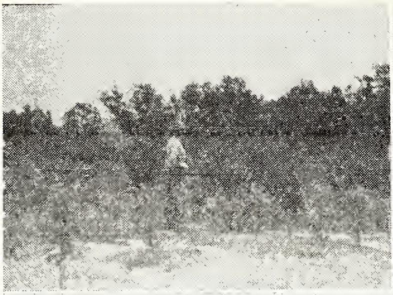


Figure 9

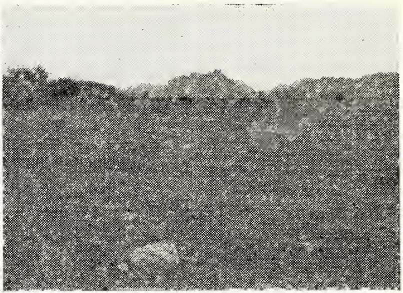


Figure 10

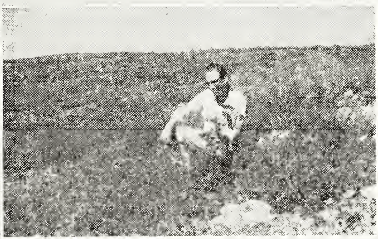


Figure 11

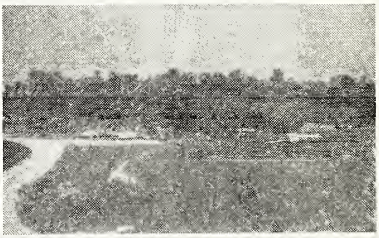


Figure 13

Figure 12

two or three years, certain calcareous spoil banks which have been properly graded and sowed with grasses and legumes can be used as pasture (Figs. 10 and 11). The impounded water supply usually provides plenty of water for livestock.

Some limitations of seeding large areas of spoil banks in pasture are that: (1) spoil banks frequently contain large rocks and boulders so that pasture improvement and maintenance are impractical; (2) pasturing capacity fluctuates widely from year to year; and (3) large areas are acid or toxic which prevents the establishment of grasses and legumes (Fig. 12).

Recreational Uses

The reclamation of spoil banks for forestry and pasture do not exhaust the land-use possibilities. A program for developing strip-mined lands into recreational areas has many promising possibilities of success. Lakes formed as water collects among the spoil banks serve as vacation spots with excellent fishing and hunting. In planning the use of these lands for picnicking, bathing, and fishing, one of the first considerations is the creation of impounded water for these purposes.

Several landowners of spoil banks have stocked their strip-mine lakes with fish. The success of their ventures depends upon: (1) the circulation of water, (2) completely covering the coal seam with water to prevent oxidation of sulphur, (3) enough vegetation growing in the water to sustain forms of aquatic life and fish food, and (4) keeping the lake floor clean of mine wastes.

Fishing affords a good potential source of income to most owners of lakes in Vigo County. For example, if one completely ignores the recreational value of fishing (and who can do that), each acre of strip-mined lakes would have a valuable resource of fish. Fish and wildlife experts state that each acre of water should produce 250 pounds of fish each year. Thus, at 250 pounds per year, strip-mine lakes within Vigo County are capable of producing many thousands of pounds of fish annually. This, of course, is in addition to benefits to the health, recreation, and revenue from fishing licenses which are incalculable. In addition, the income from the tourists and sportsmen to business concerns of strip mining areas would be another significant asset if and when strip-mine lakes are commercially developed.

Home Sites

Sections in which strip coal mining has occurred contain more non-farm settlements than other sections within the rural areas of Vigo County. Isolated non-farm settlements have increased strikingly within the strip-mined areas of Vigo County since World War II. Strip mining does not leave a continuous spoil bank that blocks off several contiguous sections. Rather, if a public road is mined out, the coal company builds a new road to replace it. Normally, the new road is a better one than the original road, and the strip-mining company then often reconstructs the original road after strip-mining operations are completed. Thus, more high-quality roads are available for use within the areas strip mined, and strip mining areas are more accessible due to a better road system. Home builders are attracted to building sites which are generally situated on unmined portions, or leveled areas near strip-mine likes (Fig. 13).

Summary

Strip coal mining modifies the landscape by developing a ridge-like terrain, burying topsoil, forming lakes, and destroying the vegetation.

In Indiana, strip coal mining companies are legally required to grade and revegetate the strip-mined land. In Vigo County, topping of the ridges to about eight feet wide is the most widely employed procedure for grading spoil banks which will be planted in trees. More complete leveling is done where areas are to be sowed in grasses or used as home sites. Compaction tests conducted by the writer indicate that compaction of spoil banks due to grading has been greatly exaggerated in most published material on the subject.

Most of the spoil banks in Vigo County are suited for trees. Forest plantings play an important role in reclamation because they help control erosion, improve the "spoil profile", conserve water, and provide recreational facilities. By the use of mixed pines and hardwoods, high-quality forests can be produced on spoil banks. Reforestation is slow, however. More intensive land uses can be accomplished by more complete grading and sowing calcareous spoil banks in grasses and legumes. In addition, the construction of earth dams in the last open cut can provide lakes for recreational areas or building sites which are often more valuable than the surrounding unmined farmland.

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Preliminary Report on the Petrology of Southampton Island, Northwest Territory[1]

Richard W. Lounsbury and Robert L. Schuster, Purdue University

Introduction

In August 1957 an expedition including scientists from Purdue and Indiana Universities carried out investigations on Southampton Island in northern Hudson Bay. This report covers preliminary findings of a portion of the geologic investigations made at that time and carried out subsequently in the laboratory.

Largest of the islands in the Canadian Inland Arctic Sea, Southampton Island is approximately 18,000 square miles in area. The island lies near the Arctic Circle, between the sixty-third and sixty-sixth parallels. Its location is shown in Figure 1. The climate and vegetation of the island are dominantly arctic in character. Average daytime temperatures during the August field season were in the low forties, and night temperatures ranged in the low thirties. Pack ice surrounded most of the island, and made most coastal areas in the central and northern areas unapproachable from the sea.

Paleozoic carbonate and Precambrian metamorphic rocks comprise the bedrock of the island. The Paleozoic carbonate rock typically forms lowlands, usually only a few tens of feet above sea level. In marked contrast the Precambrian rocks of the east coast exhibit fair relief. Here are peaks often over 1500 feet in elevation and ranging up to 1750 feet. In general, the eastern third of the island is Precambrian rock. The rest of the island is carbonate rock, frequently veneered with post-glacial beach sand and gravel deposits. This distribution is shown on the generalized geology map after Bird (3) in Figure 2.

Previous work on the petrology of the island has been general in nature. Manning (5) reported briefly on a contact observed between limestone and the Precambrian gneiss on the east coast, and Armstrong (1) recorded the presence of granite and gneiss in the eastern part of the island. He also noted limestone of Niagaran age in the extreme north and strata of Niagaran and upper Ordovician in the southwest of the island. The most complete account of the island was written by Bird (3), and this report includes physical and human geography as well as a brief description of the general geology.

Field work covered in this report was carried out from the base camp of the expedition at the Coral Harbor eskimo village and Hudson Bay post. Field investigations were made in the vicinity of Coral Harbor, in areas to the west, and along the east coast. Trips to these field areas were made by 40-foot eskimo Peterhead boats and by Norseman float

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[1] The writers wish to express their appreciation to Mr. John Buehler and the Indiana Gear Works for sponsoring this expedition, and to Professor C. W. Lovell of Purdue University for help in the field work.

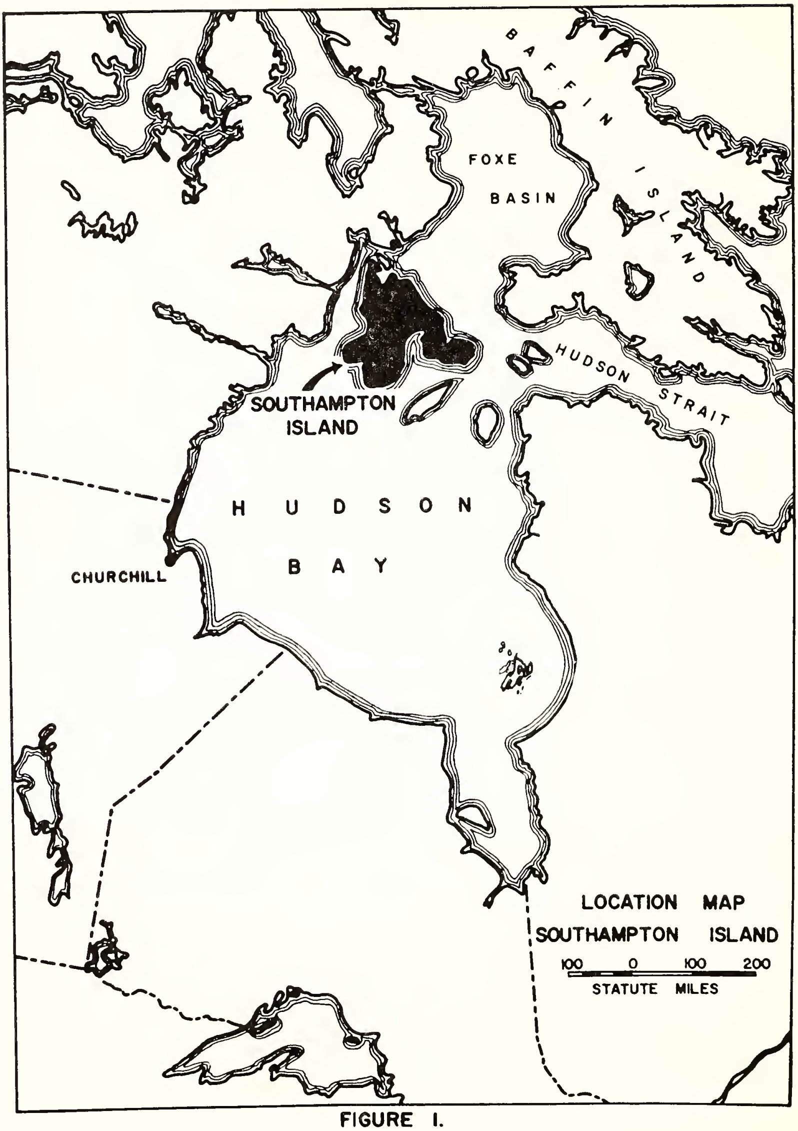

FIGURE I.

plane. Attention was directed chiefly to the study of the Precambrian rocks. Mineralogy, petrology, and structure of the crystalline rocks were investigated. Where it was possible, pace-compass traverse maps of certain areas were made. Selected samples have been sectioned and studied, and these form the basis for the petrologic descriptions given in this report.

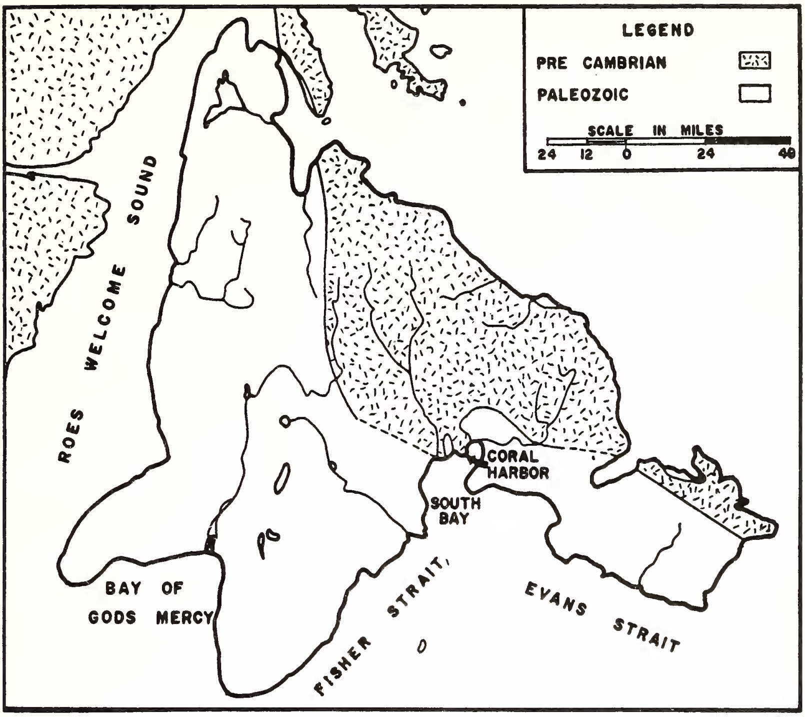

FIGURE 2. SOUTHAMPTON ISLAND GENERALIZED GEOLOGY
(AFTER J. B. BIRD)

Petrology

In the crystalline rock area, gneiss is the dominant rock type. The gneissic terrane near Mathiassen Brook in the east coast upland is shown in Figure 3a. The gneisses are chiefly pink and gray in color, and generally show good foliation. Most of the gneisses are coarse-grained, and locally porphyroblasts of feldspar several inches long are not unusual. The composition of the gneisses varies considerably. Biotite gneiss with potash feldspar, oligoclase, and quartz, and hornblende-biotite gneiss are the chief varieties. The quartz content is variable, too, and quartz-poor types are not uncommon.

A typical specimen from the vicinity of Coral Harbor contains oligoclase laths 2 to 4 mm. long, biotite and microcline with minor quartz, apatite, and magnetite. The specimen has gneissic texture and decussate grain boundaries. Another gneiss from the vicinity of Mathiassen Brook is essentially free of dark minerals with the exception of minor garnet and contains microcline 2 to 3 mm. long and a small amount of quartz. A fine-grained variety with crystals less than 0.5 mm. in length collected in this locality exhibits quartz, biotite, garnet, magnetite, and more oligoclase than potash feldspar. The texture suggests crushing and recrystallization.

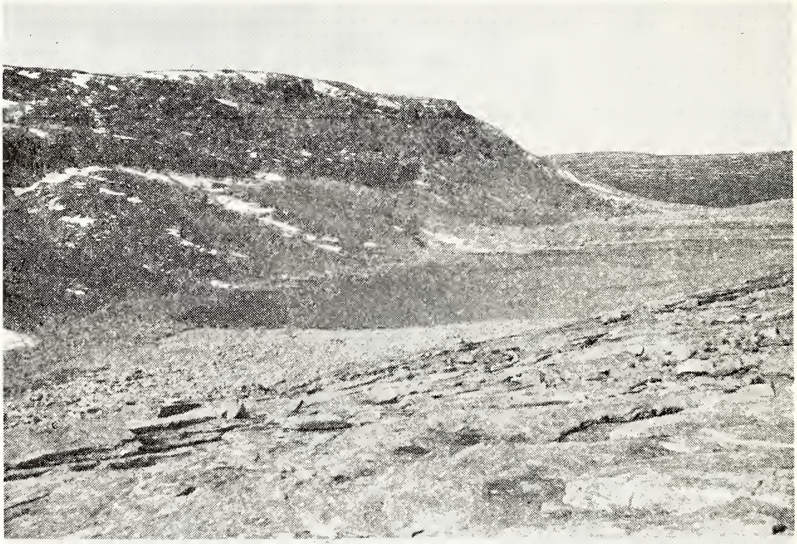

Figure 3 A

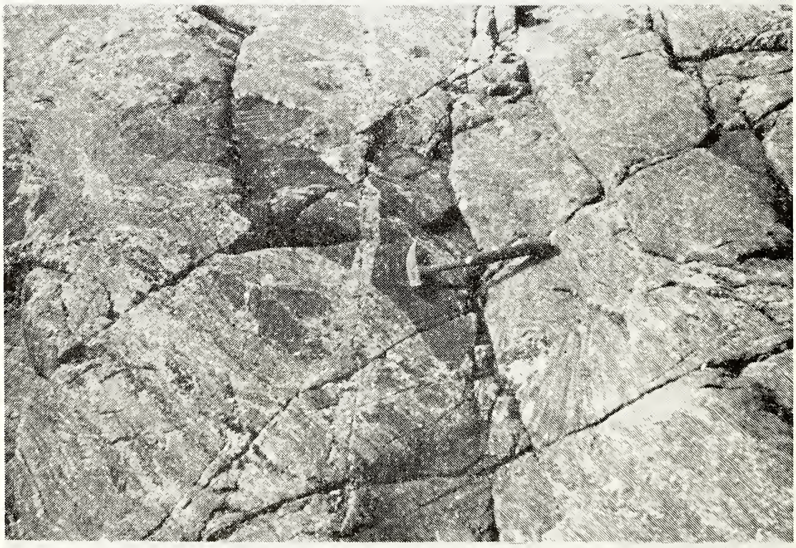

Figure 3 B

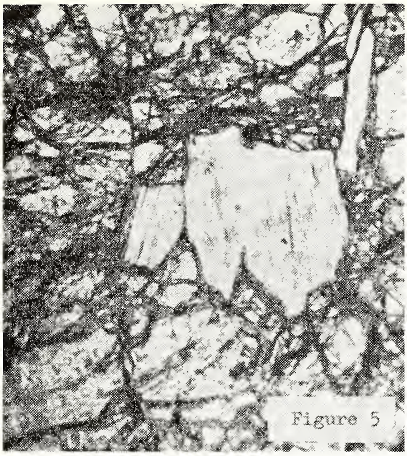

Figure 5

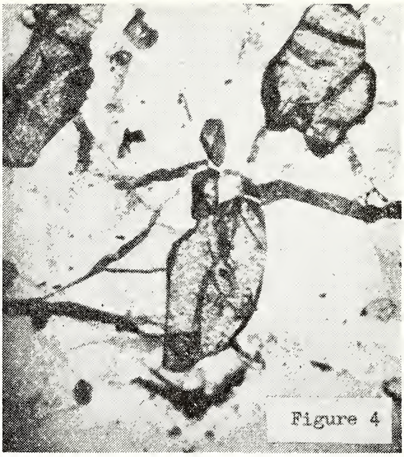

Figure 4

Garnet gneisses are fairly common, especially along the east coast. Although the garnet in these rocks is usually small, in the Mathiassen Brook area one zone in the gneiss complex contained garnets up to one inch in length. A garnet-rich gneiss is shown in Figure 4. About half of this rock is composed of garnet, and the remainder is quartz. The composition of the rock suggests derivation from an impure sandstone or other siliceous rock.

Enclosed in the gneiss complex are related schists and bands of amphibolites. Biotite and biotite-hornblende schists are most common among the former, while the latter are essentially hornblende andesine rocks, with or without biotite. Foliation of the schists is parallel to that of the gneiss, and they grade into the gneisses by increase of feldspar and decrease of dark minerals. None of the schist zones is very extensive, and most are only a few tens of feet wide and hundreds of feet long. The amphibolite zones are also very restricted. Generally these are bands less than a foot wide and of the order of hundreds of feet long. The bands are parallel to the foliation of the gneiss. In other instances the amphibolite occurs as boudins or lenses and pods up to several feet wide in the gneiss. A typical specimen from the Coral Harbor shore has decussate texture and grain size less than 1 mm. in diameter. The rock is about half hornblende and half andesine with a little biotite, magnetite, and chlorite. Amphibolite zones were found in all of the areas studied, but they are particularly abundant and well exposed along the shore at Coral Harbor. The origin of these boudins is discussed later. The amphibolite is interpreted as developing from the metamorphism of a basic igneous rock such as dolerite or basalt. The distribution and size suggest that the original rocks may have been dikes or sills.

Pegmatites

Pegmatites are abundant throughout the crystalline rock area. Figure 3b shows a typical pegmatite dike cutting an amphibolite boudin.

Most of the pegmatites are very coarse grained, pink in color, and rich in feldspar and quartz. Individual crystals 6 to 12 inches long were observed, although in most dikes the grain size was less than ½ inch. The dark minerals in these pegmatites are commonly hornblende and biotite, and in one area pegmatites were found with magnetite crystals six inches long. Most of the pegmatites are rich in quartz.

The pegmatite dikes vary in size from those only a few inches wide to ones 10 feet in width. In some areas there is a paucity of dikes, but in most areas the gneiss is literally riddled with pegmatites. Here the feldspathization of the gneiss related to growth of the dikes transforms it into granite. Foliation is absent or poorly defined in such zones.

In some areas several generations of pegmatites can be seen where dikes exhibit cross-cutting relations to other dikes. Several types of contacts are observed between the pegmatites and surrounding rock. The contact may be sharp and clearly defined with cross-cutting relations, or it may be gradational. In this case it is difficult to differentiate between pegmatite and host rock. The pegmatites also show conformable relations with the gneiss, and occur in bands parallel to the foliation. The cross-cutting relations shown by the pegmatites are believed to have originated through localization of the growing pegmatites in shear and tension cracks. The mechanical properties of the host rock have strongly influenced localization of the pegmatites, and this is particularly true of the brittle amphibolites, which are more competent during deformation than gneiss.

The field and laboratory evidence strongly suggests that the pegmatites are metamorphic in origin. The field occurrence of the Southampton pegmatites supports the points emphasized by Ramberg (6) for the non-magmatic origin of the West Greenland pegmatites. Among other points the dikes have no observable connection with magmatic bodies, and there are no proven magmatic parent rocks known. Barth (2) described pegmatite dikes with no visible channels through which magma flowed as ductless bodies, and this aptly describes the Southampton pegmatites which are enclosed bodies in the gneiss. The writers plan to continue studies of these rocks.

Ultrabasic Rocks

Perhaps the most interesting mineralogy is displayed by the ultrabasic rocks that occur as pods, lenses, and blebs in the gneiss. These rocks are composed entirely of ferromagnesian minerals, and are closely related to the pegmatites. Further study is being made of these ultrabasites, but they also appear to be metamorphic in origin. Figure 5 shows a biotite pyroxenite, one of the chief varieties of this group. Augite and biotite are the principal minerals in this rock.

Structures

The predominant structure in the gneiss is the foliation defined by the alignment of dark minerals and elongate feldspar crystals. Foliation in the gneiss is fairly uniform in given areas. Although the dominant trend is northwest in strike and steeply dipping to the northeast, some areas show nearly flat foliation. Locally the foliation may become severely contorted, and the gneiss frequently shows ptygmatic folding. One type of "crumpling" of the foliation is related to the genesis of the pegmatites, particularly the dilation-type dike.

Several stages of deformation are illustrated by the structures in the gneiss. Some features including pinch-and-swell structure of the conformable pegmatites are synmetamorphic, while other structures such as folds in the gneiss and conformable pegmatites are of later origin. In many places foliation is disrupted and becomes poorly defined adjacent to pegmatite dikes of later origin.

One of the most prominent features in the crystalline rock area is the boundinage structure of the amphibolites in the gneiss. Cloos (4) has summarized the development of thinking on the origin of boudins or sausage-shaped rock structures. An excellent description of natural and experimental boudinage has been given by Ramberg (7), who offers an origin that explains the field relations observed by the present writers. He indicates that boudinage in amphibolites originates from compression with consequent elongation, producing tension fractures in originally continuous basic bands. The fragments or blocks then tend to separate. Further tension produces "necking-down" of the separated basic blocks and sausage-shaped structures. Figure 3b shows several amphibolite boudins "necked-down" at the ends and cut by pegmatite dikes. The location of many pegmatite dikes around the peripheries of boudins and cutting across the length of the boudin, approximately at right angles, suggests growth of the pegmatite in tension and shear cracks. Such tear-drop shaped structures are especially abundant in the vicinity of Coral Harbor.

Summary

Field studies and laboratory analyses indicate that the crystalline rocks comprising the eastern third of Southampton Island in northern Hudson Bay are metamorphic in origin.

These rocks are chiefly gneisses and pegmatites with minor occurrences of schists, amphibolites, and ultrabasic rocks. The gneisses are believed to have been derived in part from siliceous rocks and the amphibolites from basic igneous rocks. Boudins of amphibolite are prominent in the gneiss, and the field relations indicate that they have formed by compression, elongation, and tensional fracturing.

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SOIL SCIENCE (AFFILIATE)

ABSTRACTS

Single Root Fertilization of Corn. A. J. Ohlrogge and W. G. Duncan, Purdue University.—Band applications of commercial mixed non-mobile fertilizers results in the fertilization of only a portion of the root system of the crop. It therefore becomes important to determine if a plant can flourish and complete its life cycle with only a part of its root system receiving essential nutrients. Six plants of single cross corn were grown to maturity in the field under conditions where at least 95% or more of the nitrogen and phosphorus was absorbed through one to three roots. Growth rate, vigor, and productivity indicated a high level of nutrition under these experimental conditions.

Effect of Different Systems of Orchard Soil Management on Soil Moisture and Water Penetration. R. B. Tukey, A. R. Bertrand and R. G. Langston, Purdue University.—Observations made during 1955 showed that in spite of rainfall which exceeded the thirty year average, apple trees under certain kinds of sod covers suffered from the lack of moisture in August and September to the point of defoliation. More detailed studies were made during 1956 and 1957 to determine what kinds of soil treatments contained the most soil moisture. The effects of various kinds of mulches, grasses, and legumes, mixtures of grasses and legumes, as well as the effects of deep tillage and soil compaction were studied. Moisture measurements and rates of water penetration were recorded.

Results indicate that present cultural practices give poor utilization of rainfall and that under such conditions soil moisture can be depleted very readily even during periods when rainfall should be adequate.

Some Aspects of Soil Compaction. C. W. Lovell, Jr.,[1] Purdue University.—Soils which are to compose an earth structure or which are to support another structure are commonly compacted to a specified unit weight-moisture content condition. The attainment of this condition is intended to provide a soil mass which is sufficiently strong, incompressible and impermeable to perform the desired engineering function.

A number of factors exert an important influence on the condition and properties of the compacted soil mass. Among these factors are: soil texture, amount and type of the applied compactive effort, moisture content at which the compaction is achieved, and the tendency and ability of the soil to change volume in the in-service environment.

This paper outlines and discusses the general nature of influence of these factors.

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[1] Joint Highway Research Project, Purdue University.

Influence of Nitrogen and Clipping on the Roots of Two Grasses. D. L. OSWALT, M. R. TEEL and A. R. BERTRAND, Purdue University.—Orchardgrass and bromegrass under high and low levels of soil nitrogen were grown in glass-sided boxes in the greenhouse and in field plots. P^{32} was used in the field to detect depth of rooting and the grasses were cut at different physiological stages.

The roots of both grasses grew 10-15 mm. more during a 24-hour period in the greenhouse where the soil nitrogen level was low. The roots reached a depth of six inches 10-15 days sooner in the field where the nitrogen level was low. The number of roots decreased and the diameter increased when the nitrogen level was high. Clipping of the plants caused the old roots to cease extention within 24 hours and a new system of roots was initiated within the top 2 inches of the soil 7-10 days after clipping.

Some Effects of Soil Physicial Factors on the Growth of Corn Roots. W. G. DUNCAN, Purdue University.—Simple tests in a uniform medium show that corn roots grow in a straight line whose slope is determined by the resistance of the medium to root penetration. They are deflected by wet filter paper and other obstructions with a fine textured surface. They are not stopped or turned by poor soil aeration or saturated air.

These observations permit reasonable conjectures about the probable path of corn root growth under various soil conditions.

The Influence of Radioactive Fallout on Agronomic Field Experimentation with Radioisotopes[1]

S. R. WILKINSON, W. G. DUNCAN and A. J. OHLROGGE, Purdue University

Radioisotopes, such as phosphorus 32, are frequently used in agronomic field experiments. The success of the experiment depends in part upon the elimination of significant ionizing radiations from other sources. Any external source of ionizing radiation increases the likelihood for error, and makes it much more difficult to detect and measure small differences due to treatment. Plant material normally contains small amounts of radioactivity, but the amount is generally insignificant in relation to the amounts normally used in biological experiments.

In a band fertilization experiment on soybeans conducted at the Purdue Agronomy Farm in the summer of 1957, an external source of ionizing radiation was discovered. The soybean treatments in this experiment were sampled at approximate weekly intervals starting on July 11, 1957. In the second sampling on July 16, 1957, approximately 15 untreated plots showed activity 15 to 18 times normal background. This high activity in the experimental plots was unexplainable on the basis of experimental design or technique. The possibility of contamination due to experimental technique was thoroughly examined, and found to be practically non-existent. The possibility of untreated soybean plant roots feeding upon fertilizer placed in adjacent rows was discounted since equally high activity was observed outside the experimental area in corn, weeds, and soybeans. Since there was little activity present in the first sampling on July 11, and very high activity discovered in the second sample on July 16, it is assumed that the radioactivity was associated with the 1.86″ rainfall which occurred on July 13, 1957.

The high levels of activity encouraged the collection of samples when convenient during trips around the state. Sixty-four soybean samples collected for a soybean nutrition survey were also used in measuring the distribution of fallout in the state. The soybean samples in this survey were taken from an area approximately 50 miles wide, extending from Walkerton to Evansville, Indiana. These plus other miscellaneous plant samples from Indiana, Kentucky, Michigan, and Wisconsin were used to determine the magnitude and probable areas of fallout in the state, its half-life, type of ionizing radiation, and the approximate energy of its radiation. Table I shows the plant sample activities corrected to July 31, 1957. The range of activity of these samples ranged from practically none in Northern Indiana to very high around Lafayette, Indiana; Louisville and Henderson, Kentucky; Patoka

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[1] Journal No. 1184, Purdue University Agricultural Experiment Station, Lafayette, Indiana. Contribution from the Department of Agronomy. Acknowledgement is made to United States Industrial Chemicals Company for funds which supported in part this work.

TABLE I

Plant Sample Activities (Counts per Minute)[1]

Number of Samples	Plant Species	Location	Date Collected	Date Counted	Range of Observed Count	Average Counts per Minute	Average Counts per Minute Corrected to July 31, 1957
15	Soybeans	Purdue Agronomy Farm	July 16, 1957	Aug. 22, 1957	204-286	242	460
34	Soybeans	North to Walkerton From Lafayette, Ind.	July 31, 1957 Aug. 1, 1957	Sept. 5, 1957	2-29	14	___[2]
30	Soybeans	South to Evansville From Lafayette, Ind.	Aug. 28, 1957 29 30	Sept. 5, 1957	21-100	57	143
6	Soybeans Ragweed Corn	Indianapolis to Lafayette, Indiana—Highway 52	July 25, 1957	July 31, 1957	112-263	200	200
4	Quackgrass Corn	Hart and Lansing, Michigan	Aug. 22, 1957	Sept. 2, 1957 Sept. 17, 1957	9-26	16	___[2]
2	Sugar Beets Corn	Chilton, Wisconsin	Aug. 27, 1957	Sept. 2, 1957	12-26	19	___[2]
2	Soybeans Corn	Near Louisville, Ky.	July 28, 1957	July 31, 1957	93-276	185	185
1	Soybeans	Hopkinsville, Ky.	Aug. 30, 1957	Sept. 2, 1957	15	15	___[2]
1	Corn	Owensboro, Ky.	Aug. 30, 1957	Sept. 17, 1957	73	73	220
2	Corn Ragweed	Purdue Agronomy Farm	July 21, 1957	Aug. 20, 1957	159-273	216	404

[1] Activity measured in an infinitely thick sample briquet, 1 inch in diameter, placed approximately one centimeter from window of Traceslab TGC—1 Geger tube.

[2] Activity below 30 counts per minute assumed to indicate negligible fallout.

and Rockville, Indiana. It appears from an examination of the rainfall on July 13th and sample activity that the amount of fallout was roughly proportional to rainfall.

The half-life characteristics of the fallout were separated into two groups, one of 18.3 days and the other 38.2 days. Since this undoubtedly was a mixture of isotopes, these half-life groups were of no value in identifying the radioactive isotopes in the mixture. The type of particle emitted was found to be predominantly beta, with probably very small amounts of weak gamma radiation. The beta particle was assumed to be negatively charged. The energy of the beta particle was determined as approximately 1.5 Mev and 1.6 Mev in two different determinations approximately two months apart. Its energy was slightly less than that of phosphorus 32. Identification of the components of the mixture was not considered within the scope of the project.

The contamination of an isotope tracer experiment is serious, particularly when the type and energy of ionizing radiation emitted is so similar to that emitted by phosphorus 32. Contamination must be considered in the analysis of the treatment differences. This means the determination of a correction factor to account for the ionizing radiation due to external sources, or fallout.

The experimental work on the fallout's effective half-life indicates that the material is sufficiently long-lived to influence activity measurements over a period of several months after its formation. This emphasizes the necessity for continuous monitoring by measuring the level of activity in the check plots.

With the increasing use of nuclear energy, nuclear weapons testing, and nuclear experimentation, it will be especially necessary to be on the alert for this new variable in all field experiments with radioisotopes. The properly designed experiment will provide a means for controlling or minimizing the effect of fallout on field experimental data.

Specific Surface and Reaction Rate of Calcitic Limestone in Neutralizing Soil Acidity[1]

HARRY MOTTO[2] and JOE L. WHITE, Purdue University

The reaction of limestone with acid soils is one of the most important reactions in agriculture. Rapid neutralization of soil acidity is desirable from a practical standpoint and there has been considerable research and education stressing the importance of using limestone having a high per cent of fine particles (3, 5, 6).

Many observations have been made concerning the effect of fineness of limestone on the rate of change of soil pH (5, 8, 9, 10, 11). A screen test is the common method of estimating fineness and the relative surface exposed. Barber (2) has shown that the per cent of limestone finer than 60-mesh is an excellent measure of the neutralizing efficiency of limestones. Barnes (4) proposed the reaction of oxalic acid with limestone as a measure of the relative surface area. He stated that the relationship between the amount of oxalic acid reacting with the limestone and the fineness of the limestone expressed as screen size was a straight line. Thomas and Gross (12) studied this reaction further and modified the procedure of Barnes (4).

It is logical to expect a direct relationship between the rate of reaction of limestone in an acid soil and the specific surface of the limestone particles. It was thought that the oxalic acid method (4) might be used to determine the amount of calcium at limestone surfaces and by consideration of the crystal structure of calcite this could be converted into specific surface values.

Materials

The limestone used in this study was a calcitic limestone from Bedford, Indiana, and had a neutralizing value of 100 percent. The material was separated into 4-8, 8-10, 10-40, 40-60, 60-100, and <100-mesh fractions and the fractions coarser than 100-mesh were carefully washed on sieves to remove surface dust.

The soil used in studying the rate of reaction of the limestone fractions was a Newton fine sandy loam having an initial pH of 4.8 and a lime requirement of 6.0 tons/acre by an equilibrium calcium hydroxide titration (Fig. 1). The titration curve (Fig. 1) is essentially linear in the pH range of 4.8 to 7.4.

Methods and Procedures

A slight modification of the method of Thomas and Gross (12) was used in an effort to estimate the surface area of the limestone fractions. One-gram samples of limestone were treated with 10 ml. of 0.1 *N* oxalic acid on the steam plate for one hour. The amount of oxalic acid reacting

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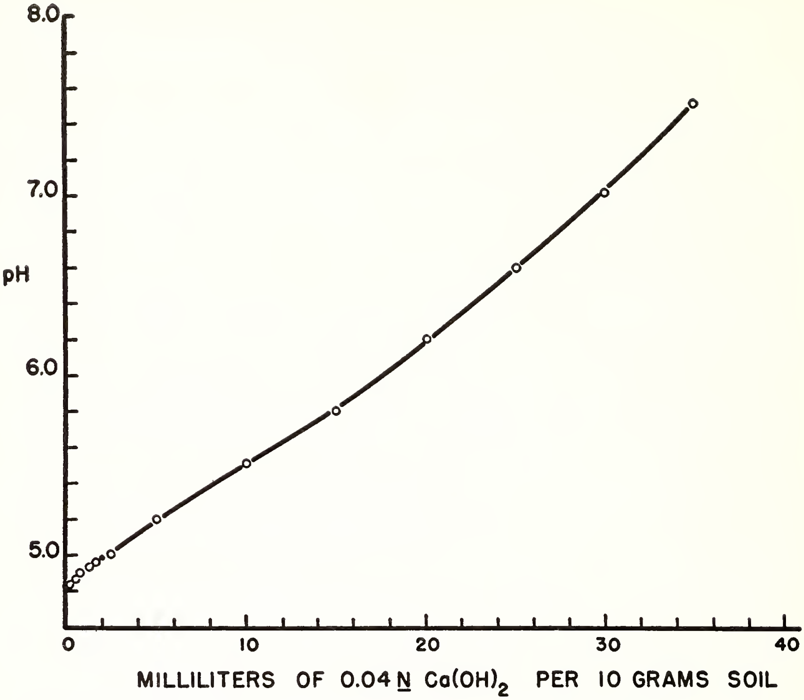

Figure 1. The equilibrium titration curve for Newton fine sandy loam with 0.04 *N* $Ca(OH)_2$

with the calcium surfaces was determined on an aliquot by titration with 0.05 *N* potassium permanganate. The calcium reacting with the oxalate was designated as "surface Ca^{++}", m.e./gram. Attempts were made to express this in terms of square meters of surface area, but calculations of the ratio of Ca^{++} per unit of surface area made on the basis of the unit cell of calcite showed the area to be much higher than that reported for ball-milled calcite by Jurinak and Bauer (7). When one considers the solubility products for calcium carbonate (8.7×10^{-9} at 25° C.) and calcium oxalate (2.57×10^{-9} at 25° C.) it can be seen that the solubility of the carbonate is about three times greater than that of the oxalate. Thus, the reaction would affect not only calcium ions at the immediate surface, but would continue until a number of subsurface layers had reacted.

Specific surface values for the various size-fractions of limestone were then calculated on the assumption that the particles were spherical in shape with a diameter corresponding to the average sieve opening for the screens used in separating a particular size-fraction. Microscopic observations of the fractions indicated this to be a reasonable assumption. These data are shown in Table 1. It should be noted here that the straight-line relationship between the amount of oxalic acid reacting with limestone surfaces and screen size, as reported by Barnes (4), could not be a valid relationship for true surface area because screen

TABLE. 1. Calculated specific surface values for six size-fractions of a calcitic limestone.

Sieve Size	Average Diameter, cm.	ΠD^2	Average No. of Particles per gram of $CaCO_3$	Specific Surface, cm.^{2}/gram
4-8 mesh	0.340	0.3631	18	6.5
8-10	0.220	0.1520	66	10.0
10-40	0.071	0.0154	1,968	30.3
40-60	0.030	0.0028	26,100	73.6
60-100	0.018	0.0010	120,833	120.8
100	0.015	0.00022	208,800	144.0

size is related to the first power of particle diameter, D, whereas surface area is a function of D^2.

In investigating the rate of reaction of the limestone fractions with the acid soil, portions of soil were treated with each of the particle-size fractions of limestone at the rate of 11 tons/acre. The samples were kept moist and pH values were measured with a glass electrode pH meter on 1:2 soil-water suspensions at intervals of 2, 4, 8, and 12 weeks.

Results and Discussion

The changes in soil pH for the various treatments are shown in Figure 2. As a relative measure of the effectiveness of the various

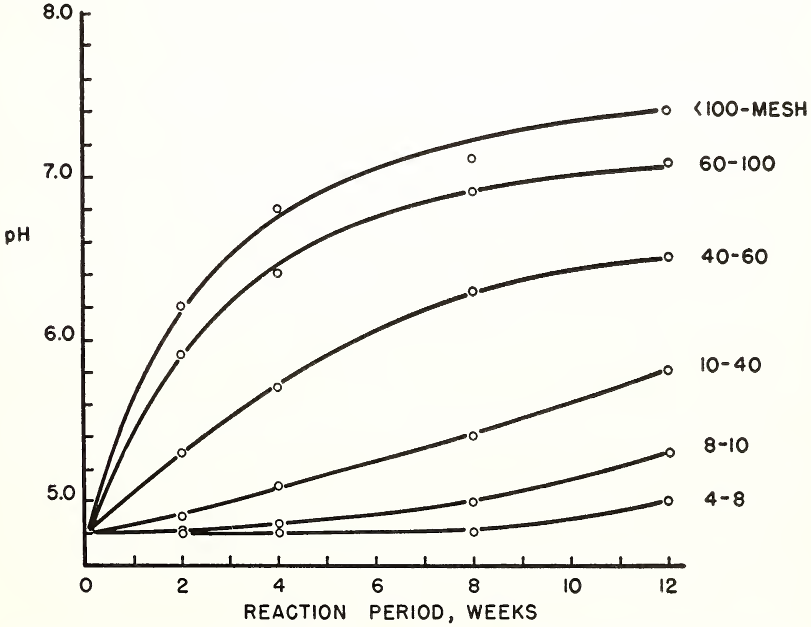

Figure 2. The influence of particle size of limestone on soil pH as a function of time.

size-fractions of limestone we have plotted the time required to produce a change from pH 4.8 to 5.0 (Fig. 3). The material finer than 60-mesh (surface area greater than 120 cm.^{2}/gram) reacted from 24 to 32 times more rapidly than the 8-10 mesh (surface area less than 10 cm.^{2}/gram) limestone in producing this change.

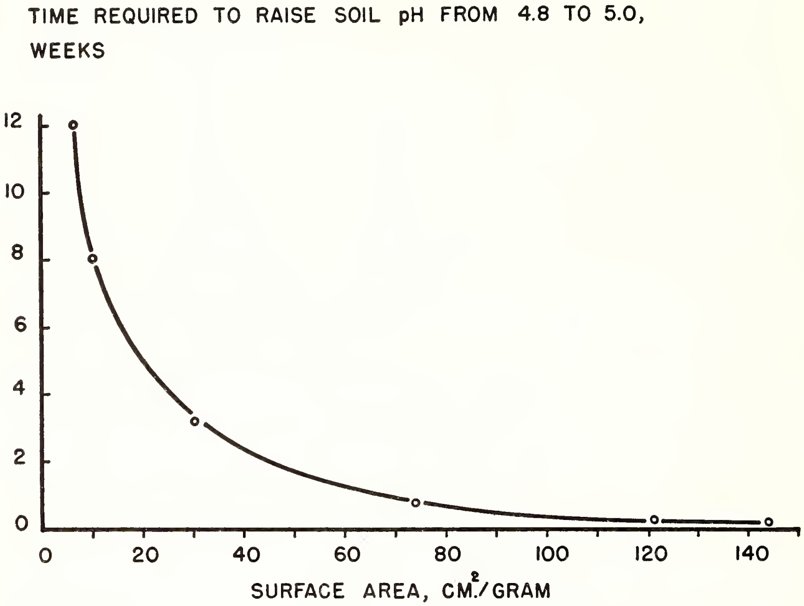

Figure 3. The relationship between specific surface of limestone and the period of time required to raise the soil pH from 4.8 to 5.0.

The relationship between specific surface and rate of neutralization should be best exemplified in the initial rate of reaction. The change in pH per week for the first two-week period was chosen as the basis for this comparison. Figure 4 shows that the rate of change in pH is very slow for the fractions larger than 40-mesh, but increases markedly for material less than 40-mesh. The increase in the slope of the curve in the smaller particle-size range suggests that the surface of the smaller limestone particles may be more reactive than that of the coarser particles.

It is suggested that this greater reactivity of surface in the finer materials may be explained in part by (1) the presence of a "Beilby" (amorphous) layer, and (2) an increase in surface energy of a crystal with decrease in particle size.

With reference to the formation of a "Beilby" layer, Adam (1, p. 177) states, "The mechanical processes of grinding always result in the formation of a certain amount of the amorphous "Beilby" layer which is obtained by polishing." Adam (1, p. 170) also cites the work of Beilby on the alteration of the structure of calcite by polishing. Beilby observed that an amorphous layer about 50 A. thick was formed at the surface

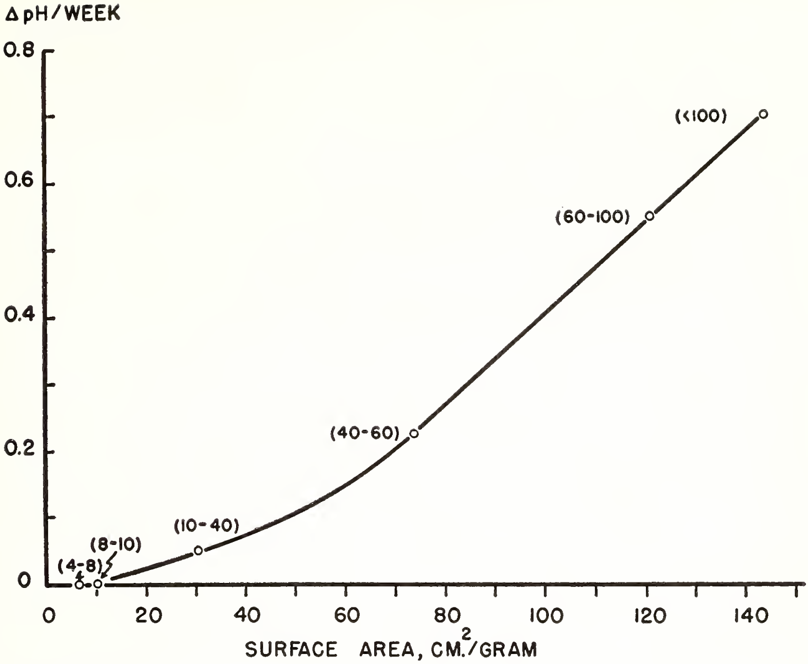

Figure 4. The relationship between specific surface of limestone and rate of change of soil pH for the first two weeks of the reaction period.

and he found traces of the effects of grinding action down to a depth of 5,000 to 10,000 A. The disruption of the structure of the crystal surface to form this "Beilby" layer results in a surface layer of greater reactivity and solubility.

Increase in surface energy with decrease in particle size of crystalline materials is analogous to the fact that the vapor pressure of a liquid in a small drop is greater than that in a large drop. Weiser (13, p. 9) referring to this analogy says, "Similarly, very finely divided particles of a solid might be expected to have a higher vapor pressure, a greater solubility, and a lower melting point than coarse crystals of the material."

Summary

The specific surface values of six size-fractions of a calcitic limestone were calculated. These values ranged from 6.5 to 144 cm.^{2}/gram for the samples studied.

The relationship between specific surface and reaction rate of limestone is neutralizing soil acidity was studied by treatment of an acid Newton fine sandy loam soil with various particle-size fractions of the calcitic limestone. The rate of reaction of the limestone fractions smaller than 60-mesh was from 24 to 32 times more rapid than that of the 8-10 mesh fraction. The relationship between the specific surface and rate of change of pH suggests that the reactivity of the surface of the finer materials is greater than that of the coarse particles. It was postulated that this greater reactivity of surface may be due to (1) the formation of a "Beilby" (amorphous) layer, and (2) an increase in surface energy with decrease in particle size.

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HISTORY OF SCIENCE

Chairman: DANIEL DENUYL, Purdue University

HOWARD MICHAUD, Purdue University, was elected chairman for 1958

ABSTRACT

History of Indiana Moss Studies. WINONA H. WELCH, DePauw University.—There are records of moss collections in Indiana from 1875 to the present, including each of the counties in the state. At least 96 articles have been published concerning Indiana bryophytes, the most recent publication being a book of 478 pages by this author, entitled Mosses of Indiana, treating 25 families, 92 genera, and 260 species, varieties, and forms known to occur in the state. Among the least collected mosses of the state is *Grimmia trichophylla* var. *indianensis*, so named because the type specimen of this variety was collected in Indiana.

Forests of the Lower Wabash Bottomlands During The Period 1870-1890

DANIEL DENUYL, Purdue University

Shortly after the passing of Charles C. Deam in 1953 it was my good fortune to receive from Mrs. Ortenburger (Deam's daughter) a few items from Deam's collections. Among them was an envelope on which Deam had typed, "This set is very valuable, photos by Robert Ridgeway, with key in his own handwriting." In the envelope were photographs taken in Indiana and a letter describing the forests of the Lower Wabash Bottomlands.

In response to an invitation to visit Knox County, Indiana which was extended to Robert Ridgeway by Charles C. Deam, Ridgeway replied with a letter dated August 2, 1919 and postmarked Olney, Illinois.

The letter and photographs describing the forests of Knox and Gibson counties as Ridgeway knew them during the period 1870-1890, as far as I have been able to determine, have not previously been published.

Ridgeway's letter is in part as follows:

"I wish it were possible for me to join you in Knox County. Unfortunately my time is not my own, and as I have long ago used up my annual leave I am able to make short trips to the woods, hereabouts only on Sundays, of evenings or holidays.

"Yes, although I have not been in Indiana on foot since 1890, I know that my old 'stamping grounds' have been completely transformed. In truth, it was knowledge of this fact, more than anything else, which induced me to establish my home here rather than at Mt. Carmel where I was born. The transformation is indeed more radical than could possibly be realized by anyone not familiar with the forests of the Wabash bottom as I knew them in the "seventies" Then there was scarcely a break (only here and there a farm hewn out of the forest, or, more rarely, a small settlement), from a little below Vincennes to near New Harmony, an exceedingly heavy virgin forest, some of the heaviest hardwood forest I have ever seen—as I have twice visited the Tropics (Central America)—covering almost the entire flood plain of the Wabash on the Indiana side. I am sending you some photographs, taken as late as 1888, showing the continuous character of those forests, though at the time the photographs were taken there had been considerable 'culling' of the best trees.

"I am perfectly well aware that I have been accused of MUNCHAUSENISM in the matter of measurements of trees which I have published, but was always ready to take up a challenge when proof was possible. You are probably aware that exceedingly few people are able to guess with even approximate accuracy the height of a given tree. On a certain occasion I asked estimates of the height of a tree from several timber cutters, and their estimates ranged from 80 to 'nigh onto 200 feet.' When I measured the big sycamore of which I send

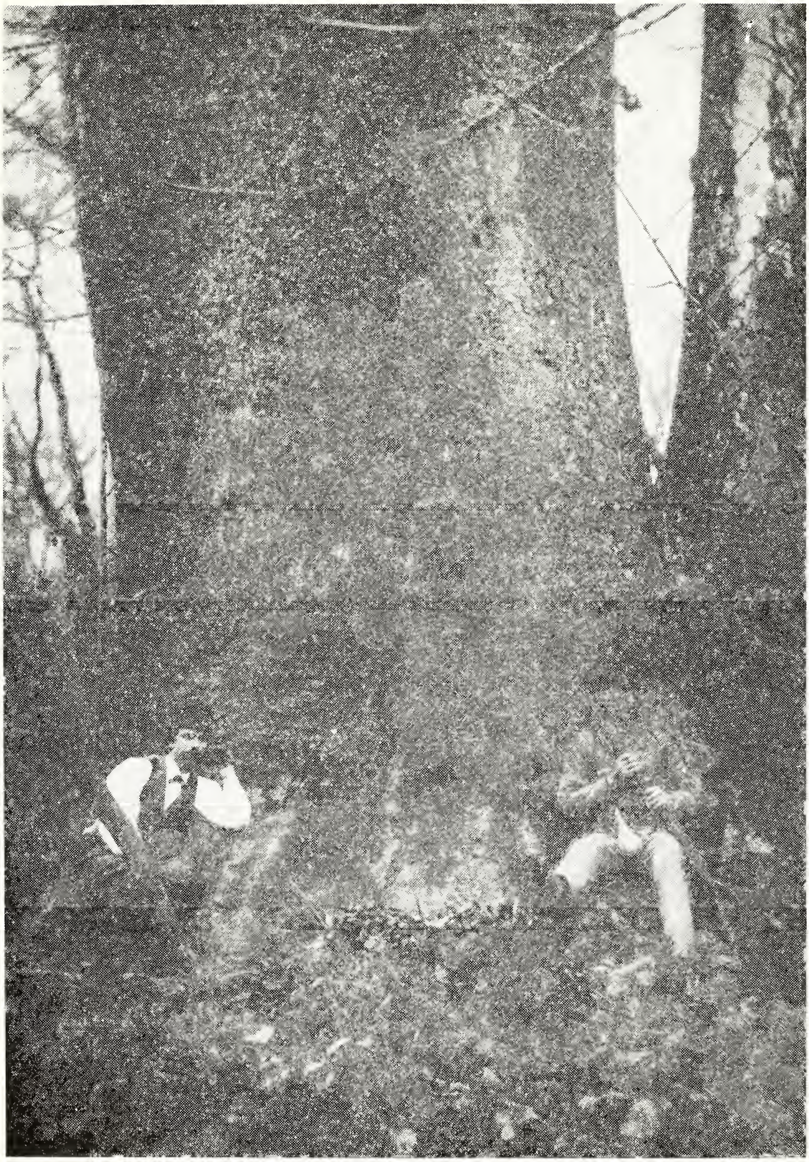

Figure 1.

you a photograph, it then stood near the middle of an immense cornfield. A man plowing at the farthest corner observed my antics. At first he was content to halt his horse and leaning on the plow handle observe my movements, but at last he could retain his curiosity no longer, and, hitching his horse, sauntered across the field to where I was at work and, good-naturedly, asked what I was doing. I told him that I was measuring the height of probably the tallest tree east of California He looked both surprised and incredulous; then squinting up toward the top of the tree remarked, 'It is a purty good chunk of a tree, ain't it?' Evidently its size had never impressed him before.

"Big Sycamore in Gibson Co. nearly opposite Mt. Carmel, Ill. Diameter 15 ft. at 10 ft. Height as determined by dendrometer. Tri-

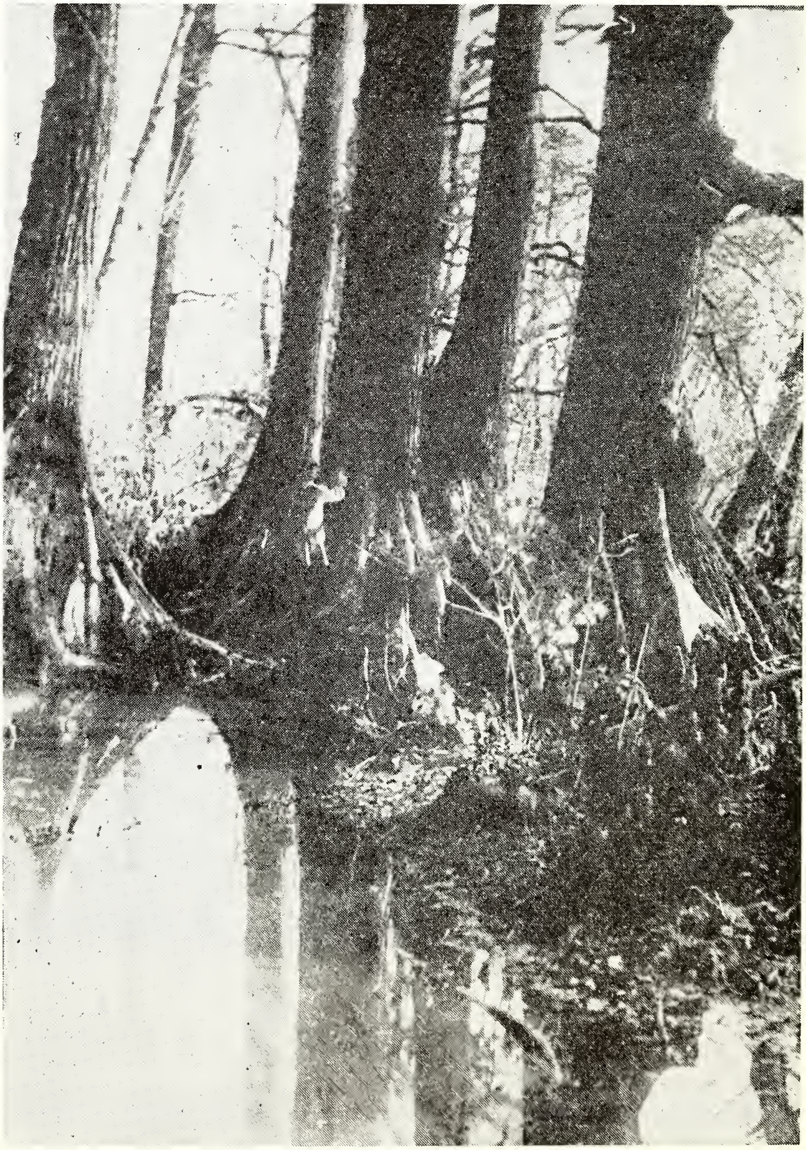

Figure 2.

angulation and measuring shadow at noon—average of these—160 feet, spread of top 134 x 112 feet. This tree stood in a partially cleared portion of the heaviest hardwood forest I have ever seen—the Tropics not excepted. On the same half mile square (approximated—the area may have been much less and certainly was not greater) I measured on this same day, twelve sycamores which averaged near 8 feet (average girth 23½ feet) in diameter and 127 feet spread of top. This especially heavy forest stretched from a short distance below the mouth of Patoka River to Coffee Bayou and in it the only buckeye trees I ever saw in the Wabash bottom. I think the species must have been Aesculus octandra, as the trees were too large for Aesculus glabra, according to descriptions, being 70 or 80 feet high and 2 feet or more in diameter."

"When it is considered that in the bottomland of the Lower Wabash all the conditions existed—deep, fertile, well drained soils, with constant moisture, for the very best development of tree growth and that the stand (in the original forest) was so thick that the trees *had* to grow upward toward the sunlight, it is no wonder that many species grew to a height that seems improbable to some people. My estimate was that the 'tree top line of the virgin forest along the Lower Wabash was not less than 100 feet and it may have been as much as 120 feet. It was remarkably uniform, forming a practically straight, level line, with only here and there the dome-shaped top of some species which grew larger than most others, usually a sycamore, pecan, a Schneck's Oak, or tulip tree, lifted a little above the general level. One hundred feet high seems a marvelous height to many people; yet is is a fact that it doesn't take very much of a tree to reach that height in a crowded forest."

A discussion of species characteristics follows and then Ridgway returns to the forests of the Lower Wabash.

"Reverting to the subject of profound changes in Knox County, I came near forgetting Monteur's Pond and vicinity. When my parents lived on a farm near there it was a wooded swamp, about 9 miles in length and 1 mile in average width. The greater part was densely wooded, the prevailing trees being tall willows (S. nigra), red maples, swamp cottonwood, black ash (the only place, by the way, where I ever saw the last growing). About 1889 or 1890 it was drained and now, judging by appearances from the train in crossing through, it would be difficult to find a stick as big as a broom handle on the entire area! Among the photographs which I send are two showing the character of this swamp as it was in 1885. I hope sometime to get the chance to revisit the locality and take other photographs from the same points. One could not imagine a more profound change. (As late as 1885, practically the whole region about Monteur's Pond was heavily wooded except where farms etc., had been cleared. Yet in 1910, when A. H. Howell, of the Biological Survey, passed through on his way from Washington to Olney, he entered in his notebook 'a prairie-like country.'!!!"

Robert Ridgeway, a well known Ornithologist was born at Mt. Carmel, Illinois on July 2, 1850 and died on March 25, 1929. For a few

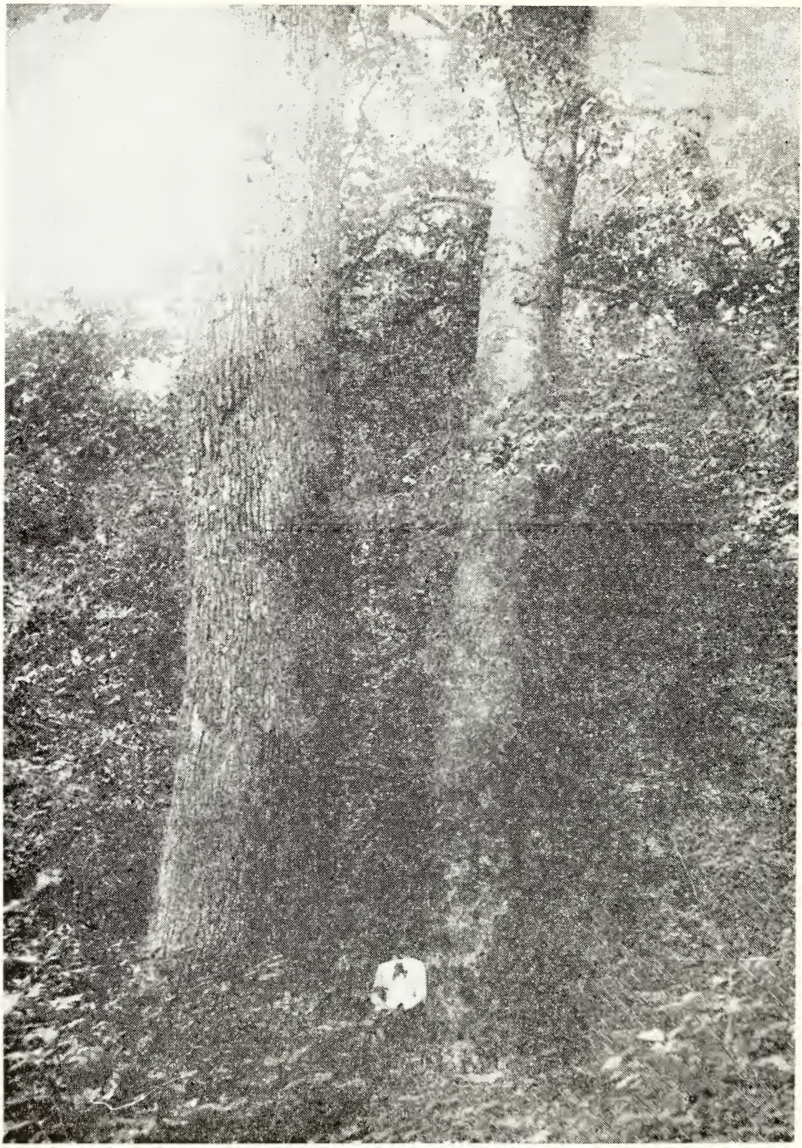

Figure 3.

years he lived near Wheatland, Indiana and during his early years he spent much of his time in the Lower Wabash Bottomlands studying birds and the vegetation.

Aspects Of The Wiser Use Of Indiana's Soils

Stephen S. Visher, Indiana University

The soils of Indiana are much more effectively used now than 140 years ago, when statehood commenced. Improvements have occurred in several respects: 1) tillage is much more effective. In the early years, plows were poor, and little of the land was well-prepared for crop growth. The rapidity of plowing now possible with tractors makes it commonly possible to prepare the seedbed when it can be plowed well, while formerly much land was plowed when it was too wet. Deeper plowing, including subsoiling, now is more widely practiced. Cultivation has greatly improved with the help of new equipment and more extensive knowledge. One of the somewhat surprising developments to those who cultivated crops fifty or sixty years ago is that now much land is less deeply cultivated than formerly, and less often.

2) The drainage by ditch and tile of much land formerly too wet for successful cropping has been a major improvement in Indiana. Indeed the nearly one-third of the state which formerly had little or no agricultural value because it was poorly drained has become the better crop land of the state. Drainage required decades of hard labor, and many tracts proved not worth the cost of draining. A major reason for the financial failure of various drainage projects was inadequate outlets for the vast amounts of water yielded by the occasional very heavy rains. Compaction of the soil as the humus oxidized was another drawback. Numerous areas well-drained by tile when it was first installed became after a time poorly drained as a result of changes in the soil. Drainage ditches and tile have been supplemented by levees or dykes to hold out flooded streams. Levees to the total length of more than 100 miles have been constructed along or near the lower Wabash River. Tile to a total length of more than 200,000 miles have been laid in Indiana, and drainage ditches with a total length of more than 30,000 miles have been dug.

3) The counteracting of the prevailing excessive soil acidity characteristic of our soils originally by the adding of pulverized limestone has greatly increased the yield of crops. Indeed liming of the soil has often doubled the average crop yield as compared with nearby unsweetened soils. This great improvement has occurred chiefly during the last 30 years. Indeed for several years under the New Deal, the farmers were supplied pulverized limestone almost free or were paid a bonus for using it.

4) Soil productivity has been conspicuously increased by growing crops which are more productive under the climatic conditions which generally prevail here than were the crops grown a century ago. The introduction and widespread growth of hybrid corn, soybeans, tomatoes and improved varieties of each of them and of wheat, oats, hay, and of many other crops have enormously increased yields. Likewise there has been a better adjustment of crops to soil. Special types of soil

are devoted increasingly to special crops which have been found to grow comparatively well in such soils. Examples are melons in sandy soil, onions and potatoes on muck land.

5) There has been a great increase in the amount of fertilizer used, and greater skill in its use. Seventy-five years ago almost no mineral fertilizer was used in Indiana while now many millions of dollars worth is used each year. Recently in addition to the three customary mineral fertilizers, nitrate, phosphate and potash, various lesser ones have been found to contribute locally notably to yields of certain special crops. Examples are boron, cobalt, copper, and manganese.

6) Irrigation is another technique which has greatly increased yields locally in Indiana. For several decades, a little sprinkling has been done of market gardens, house gardens and lawns but in very recent years many thousands of acres of crops have been irrigated in Indiana with the help of electrically driven pumps and aluminum pipes. Experts at Purdue estimated in 1955 that some fifty thousand acres were irrigated in Indiana, mostly of hybrid seed corn, a very valuable crop. The increased demand recently for water for irrigation is of more than local significance. For example, water-supply experts have estimated that if all the river bottom land along the White River were irrigated, and many land owners there desire to irrigate, there would be left in the river during seasons of low water an inadequate supply for the cities and industries further down stream. One of the arguments in favor of constructing the large reservoir in Salt Creek valley between Bloomington and Bedford is to supply water for great coal burning power plants which might logically be erected in the coal field along the lower Wabash, if the large amounts of water needed by such power plants is available.

Fifty years ago few people indeed thought that so much land would ever be irrigated in Indiana. But with higher prices for land, increased costs of the care of crops, and higher prices for crops, the time is approaching if not already here, when one of the major manners of increasing the productivity of Indiana's soils will be more irrigation.

7) An early improvement of increasing the usefulness of the soil was the clearing away of the trees and their stumps, and in a few areas, the removal of glacial boulders. Removal of the forest from the approximately nine tenths of our state which was wooded permitted a great increase in crop yields. The removal of stumps and stones facilitated the use of machinery.

8) Methods of combating weeds and parasites have also greatly improved. Although total yields continue to be seriously diminished by weeds, fungi, insects, worms and other animals, much progress has been made partly with the help of chemicals.

The total effect of all the improvements in the more effective use of the soil here mentioned is to vastly increase the annual returns from the soil. However, unfortunately there has been a serious loss of soil by soil erosion. Experts estimate a considerable loss of top soil has occurred in more than a third of the state and that about one-ninth of the state has suffered severely from erosion.

The Extent of the Effectiveness of Natural Selection

WILLIAM J. TINKLE, Anderson College[1]

In his "History of Biology," Eric Nordenskiold draws this conclusion concerning natural selection: "that it does not operate in the form imagined by Darwin must certainly be taken as proved, but does it exist at all?"(8)

No one denies that Charles Darwin's doctrine of evolution by "natural selection" or Spencer's paraphrase "survival of the fittest" has had tremendous influence. The promulgation of this idea must be given credit for the acceptance of evolution. Before the time of Darwin there were several men, such as Buffon, Goethe, and Lamarck, who believed that organic species were developed by natural forces rather than having been designed by a Creator, but most scientists doubted their doctrine. When a method was advanced, however, by means of which evolution might come about, a majority of scientists accepted evolution, agreeing with Darwin that present plants and animals developed from simple protoplasm by a series of small changes, rather than originating as well organized types.

The operation of evolution by natural selection is based upon the following assertions:

1. Organisms produce more seeds, eggs, or young ones than can grow to maturity under average conditions.
2. This prodigality of reproduction, along with the vicissitudes of nature, result in a struggle for existence in which a majority of plants and animals die.
3. Organisms vary slightly from their parents in every conceivable direction.
4. In the struggle for existence, those individuals which chance to have favorable variations live and produce offspring, while the balance perish.
5. These variations are heritable, and are not only passed on but also accentuated in future generations, until the individuals differ enough from their remote ancestors to be considered a new species.

Extent of Agreement

The first of these assertions is a matter of common observation and no one denies that nature has great potential powers of reproduction. The other four, however, have been foci of much dispute.

At present, biologists agree that the vicissitudes of nature along with competition tend to eliminate those plants or animals which are markedly below the average. For instance, in nature we find few or no notably weak individuals such as are found in the breeding plot or laboratory, in which places we endeavor to save the life of every plant or animal. There is no reason to think that weak forms do not appear in nature but they soon lose their lives. On the other hand, in areas where man has interfered with nature, Pennsylvania for instance, where predators have been killed and deer protected, natural selection is impeded, with the result that albino and crippled deer are found rather frequently.

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[1] I am indebted to Dr. Edwin Y. Monsma of Calvin College for reading this manuscript.

It seems that biologists agree that natural selection tends to set a lower limit, thus maintaining a standard of health and vigor. But beyond this principle there has been much disparity of thought, which we shall proceed to discuss.

Indefinite Terms

It has been pointed out that the natural selection doctrine bears the stamp of a scientist's reasoning rather than of experimentation and quantitative reports, such as are characteristic of most twentieth century investigations. Weissman (5) himself a proponent of selection, admits, "We can usually not prove that any given adaptation is due to natural selection." Oscar Hertwig (5), finding very little in selection with which to agree, complains, "The formulae of explanation, 'struggle for existence,' 'survival of the fittest,' 'selection' are very vague expressions, which only gain scientific value by the mode in which they are applied in the concrete case."

One is inclined to agree with Hertwig when he observes the great diversity of plants and animals living together, in an environment which can not be so very diverse. Why has that big shell resisted the surf? It must be very hard and resistant. Why has that fragile little shell also survived? It must have been able to fall into the cracks between the stones. While these examples do not come directly from Hertwig, they are in line with what he says about the indefinite meaning of the expressions used. Employing them, one can not predict that a certain habitat will develop a certain type of species to the exclusion of others.

Some Influences Not Mentioned

It is natural that people base their doctrines upon certain ideas which they assume to be correct, without having proved them to be so. It is well that these assumptions be stated, however, as a geometrician states his axioms, and Thomas Jefferson writes, "We hold these truths to be self evident."

Natural selection seems to be founded upon the assumptions that animals are selfish and ruthless almost without limit. Once in a while an example favors this idea, as when a weasel kills a whole flock of chickens, many more than he can devour or even suck the blood. But Long (7) writes that in his experience, bears, wolves, and other carnivores kill only when they are hungry, they kill quickly, and only as many as are needed.

Douglas Dewar (2), an ornithologist of India, has this to say: "The general rule in nature is, 'Never fight when a fight can be avoided.' The most familiar example of the rule in operation is the well-known habit of birds surrendering their perches to new-comers. When individual A flies to a perch occupied by individual B the latter almost invariably gives way without demur. The particular perch is of no value to the occupier, but a whole body may be a matter of life or death."

Now it is true that Darwin did not write so much of actual combat as of competition and more subtle struggle. But Hertwig (5) counters that organisms die in large numbers, not from struggle, but from cold, starvation, and the like. It is easily seen that if no individual had been the recipient of a variation which would enable it to live with less food or less heat, in such a case natural selection would cause no change in the next generation because the survivors would be no different from the ones which perished.

As I have discussed elsewhere (11), the "Origin of Species" was written at a time and place where ruthless and unrestrained competition was going on in industry and commerce, and Darwin broadened this human situation to include the whole organic realm. During the half century which followed, the idea of struggle became so popular that writers sought for it almost everywhere. Weissman (12), in his very influential book, "The Germ-Plasm," speaks of struggle for expression among the ids (genes). But modern geneticists have not found this fight for supremacy; on the other hand, the recessive gene regularly yields to the dominant gene and so becomes latent.

Perhaps the least mentioned assumption of this doctrine is that an organism of high organization has an advantage in the struggle for existence, since it is claimed that this struggle accounts for the origin of high organization. But this reasoning raises the question as to how the simple animals continue to survive, and even thrive in some cases. Darwin (1) saw the question more clearly than the answer, as shown by the following remark: "for what would it profit an Infusorial animalcule, for instance, or an intestinal worm to become highly organized?" What indeed! But according to the theory they should either become better organized or else decrease in numbers.

If animals developed specialized structures as a result of the advantage conferred, what shall we say about the opossum, *Didelphys virginiana*, which has generalized teeth and legs and a very little brain, yet increases in numbers. Vernon Bailey (4) measured brain size by filling craniums with beans, securing the following results: opossum 21; skunk 35; Arctic hare 46; porcupine 70; red fox 198; coyote 325; gray wolf 438. Hartman (4) says, "Stupidity runs in the family. This branch of the animal kingdom stood still in the process of evolution, outstripped by its competitors, the higher animals."

But this abundant marsupial has increased its range from the Middle Atlantic States into New England, and introduced into California it has become abundant on the Pacific coast. For some reason, nature has favored an artless, unspecialized animal, perhaps through its omnivorous appetite.

Yet the opossum is not an exception but an example of organisms of low organization and success in survival. Hydra has but two cell layers, no skeleton, brain, nor stomach, yet it devours the complex crustacean Daphnia, and shows no indication of a decrease in numbers. Among plants the tall ones shade out the shorter ones, even though the tall ones may be less highly organized. It seems doubtful if natural selection should be credited with the origin of highly organized species.

Nature of Variations

Much of the opposition to the selection theory in the nineteenth century was from the environmental school. Lamarck and his disciples taught that the response of the organism to environment, use, and disuse was passed on to succeeding generations. All modern geneticists (10), with the exception of a group in Russia under political domination, are agreed that such effects can not be found in experiments. It is true that geneticists do not deny the effects of environment upon plants and animals themselves, but contend that such an effect does not recur in a succeeding generation apart from the environment which called it forth.

Direct effects of radiation upon germplasm do create an hereditary effect, but this is not a response of the organism; rather, a direct, deleterious effect upon the germinal material, resulting in mutation or chromosomal breakage.

The authors of natural selection did not classify variations, but most of them are environmental or acquired characters, which simply drop out of the picture at the end of a generation. The other variations are either the reorganization of a gene called a mutation or a change in the configuration of chromosomes. Some geneticists apply the name mutation to both. Since hereditary factors do not change gradually but only at mutation, species are immutable, that is, unchanging, between mutations. To be sure, if a pair of chromosomes contains unlike members of a pair of genes—the heterozygous condition—there will be diversity in the offspring; not new characters, however, but recombination of characters which have appeared before. Characters which are new, not latent in the germplasm nor called forth by the environment, arise only at mutation.

The present proponents of evolution by natural selection are the Neo-Darwinists, who hold that nature selects among mutations rather than among variations in general. This new front makes the process of evolution much longer and harder to visualize, for many species mutate only once in a million generations on the average. Adding to the difficulty is the recent statement by Dobzhansky (3), which often has been made before, that "Most mutations are more or less injurious to the organism." Indeed this statement is so true that one can name the observed beneficial ones on his fingers, and even the most of them are doubtful.

If this paucity of observed changes seems strange, one needs only to go to cytology to see the care that is taken to prevent change. In mitosis, in maturation of gametes, see how exactly the chromatin, indeed each separate chromosome, is divided and the halves pulled to the forming daughter cells.

In the light of the above facts, it is to be expected that in the absence of mutation, which usually is true, the effectiveness of selection will diminish and finally cease. In a given population, man selects repeatedly a limited type as seed stock, discarding all the rest, until much homogeneity is attained. If a point is reached at which all individuals in the population are alike in their germplasm, it does not matter which one is chosen as seed stock, the progeny will be the same.

Such results indeed are observed in breeding, for instance in increasing the sugar content of beets. The sweetest strains of the ordinary table beet were selected for the commercial production of sugar, with the result that improvement was rapid at first. From 1800 to 1878 the percentage of sugar was increased from 6 per cent to 17 per cent (6). Encouraged by such success, selection was continued for forty years, but there was no further increase in sugar content.

According to present data, there is no reason to think that natural selection produces greater results than man's selection. More time is involved but the limiting factor is not time but contained genes. And while it is true that mutations may cause marked changes, they are so rarely beneficial that natural selection seems inadequate as a basis of organic evolution. It does, however, seem to set a lower limit in vigor and thus helps to maintain a standard.

Is There Another Basis?

In view of the above difficulties, we wonder if any other basis for evolution is better. Do we have observed data for orthogenesis or for creative evolution? Could we not agree with Heribert-Nilsson (9) of Sweden that the only kind of evolution which has occurred is a series of reductions of the original germplasm? Since the natural selection theory brought about the original acceptance of evolution, what do we do, now that selection is largely discredited?

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History of the Early Development of Game Regulations in Indiana

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The first game law for the protection of our diminishing wildlife in Indiana was enacted in 1857. The legislature passed an act in February of that year making it unlawful to kill, shoot, trap, or ensnare any deer, buck, doe, or fawn during a closed season from January 1 to August 1 of each year. A closed season on wild turkeys, quails, pheasants, and prairie chickens was also established with small penalties.

Other laws followed which were intended to protect fish and game that were known to be in danger of depletion. In 1867 the first legal protection was given to fish by the state legislature. This law made it unlawful to trap, net, or seine fish within two years and thereafter between May 1 and September 1 of any year. In 1871 it became unlawful to spear fish during March, April, November, and December. Minnow seining was also regulated. In 1873 a bill was passed to protect song birds. Fines of $1.00 to $10.00 were provided for killing any turtle dove (mourning dove), meadowlark, robin, mocking bird, blue bird, wren, sparrow, red bird, pewee, martin, thrush, swallow, oriole, yellow hammer, or catbird. Woodcocks and ducks received protection in 1877 by providing closed seasons from January 1 to July 1 for woodcocks and from April 15 to September 1 for ducks.

From the beginning, Indiana followed the traditional pattern of other states in its attempt to help maintain wildlife. This included the following evolutionary steps: (1) game laws, (2) predator control, (3) game refuges, (4) artificial propagation, and (5) game management on the land.

The primary purpose of this discourse is to trace the early history of game laws, hunting regulations, and the attempts at artificial propagation which preceded and led up to the present scientific methods of game management on the land.

Up to the establishment of the Indiana Department of Conservation in 1919, the protection of the state's fish and game resources were under the jurisdiction of first, the Commissioner of Fisheries, and in 1899 the position was changed to the Commissioner of Fish and Game. The office of Commissioner of Fisheries was created by the legislature in 1881, and Calvin I. Fletcher, Spencer, was appointed by Governor Albert G. Foster to the position in September of that year. An appropriation of $2,000 was made for expenses and the salary of the Commissioner was $300.

In 1885, Enos B. Reed of Indianapolis was appointed Commissioner by Governor Isaak P. Gray. Little could be accomplished since the legislature in 1883 had cut the appropriation for expenses to $1,000. Mr. W. F. Dennis was appointed Commissioner in 1889 by Governor Alvin P. Hovey and served until 1893. It was during the latter's term of office that road supervisors were empowered to make arrests for game and fish violations. In addition, Mr. Dennis organized a State Fish and Game Protective Association, hired detectives to apprehend violators, and succeeded in convicting about 100 offenders during his first two years.

Up to this time all of the Commissioners believed that legal protection was the only way to bring back the state's diminishing fish and game. Fish were being taken by nets, seines, traps, and by the use of dynamite and poisons.

Mr. Philip H. Kirsch of Columbia City was appointed Commissioner by Governor Claude Mathews in 1893 and served until 1897. He was the first to register strong complaints against pollution, stating that the "streams were being used as a dumping place for everything that men and hogs couldn't eat."

In 1897, Governor James A. Mount appointed Mr. Z. T. Sweeney of Columbus as Commissioner. Many changes in the fish and game regulations occurred during Mr. Sweeney's term which continued until 1910.

The legislature passed a statute in 1897 broadening the duties and power of the office. This gave Mr. Sweeney the power to appoint deputies in every county although no provisions were made for salaries. Deputies could appear for the Commissioner along with the prosecuting attorney and a $10 fine was assessed in case of conviction.

It was under the 1897 law that the first real concentrated effort for the protection of fish began. In his first biennial report to the Governor in 1899, Mr. Sweeney emphasized the commercial value of fish to the state and made the following recommendations: (1) that the cities and towns be made to take care of their sewage, (2) that dynamiting fish be made a felony, (3) that a closed season on fishing be established from May 1 to July 1, (4) that seining be limited to seines not over 100 feet long, 8 feet deep, with meshes of 2 inches or more, and requiring a license fee of $1.00 for their use, (5) that a 9 inch limit be set on bass, (6) that selling of fish be prohibited for three years. He also advocated uniformity of laws between the state, police power for his deputies, a state fish broodery, and that the game of the state be placed under his charge. He asked for an annual appropriation of $7,500 with $1,500 for salary and $1,000 for expenses.

During the same year (1899), the legislature passed most of the recommendations including the repeal of the 1881 law creating the Commission of Fisheries and establishing a new office of Commissioner of Fish and Game with a four year term. A salary of $1,200 was allowed with an additional $1,200 for expenses.

In 1901 the legislature enacted the following game laws: (1) water birds could not be shot from launches nor shot before daylight or after dark, (2) a perpetual closed season was placed on deer, wild turkey, and pheasants, (3) all hunting was prohibited from October 1 to November 10, except for squirrels and waterfowl which could only be shot on permit from the Commissioner, (4) it was made illegal to sell or buy pickerel, pike, perch, walleye, bluegills, black bass, green bass, rock bass, or any other bass, and a limit of 10 inches instead of 9 inches was placed on bass, (5) the license to seine was abolished and possession of seines, nets, spears or traps was made illegal, (6) Sunday hunting and hunting without permission of the landowner was illegal, and (7) the Commissioner was given the power to appoint deputies at $60 per month except for the chief deputy whose salary was to be determined by the Commissioner.

In 1903, Mr. Sweeney recommended a license fee of $1.00 to hunt. He reported that 700 English ring-necked pheasants had been stocked in the state. The hunting license was not passed except for those who wished to hunt waterfowl from October 1 to November 10 when other hunting was prohibited. The license required the photograph of the person to be attached. The legislature appropriated $7,500 for operating the office including $1,200 salary for the Commissioner and $800 for expenses.

In 1905 the legislature passed the first law requiring every person to take out a license to hunt out of his own township and non-residents had to pay $15.50. The new license greatly increased the revenues and the Commissioner had about $20,000 per year with which to work. An attempt was made by Mr. Sweeney to establish a hatchery for pheasants at Madison in 1904 but after three years he reported that little progress had been made in rearing the birds.

In 1907 the license law was changed so that land owners could hunt only on their own land without a license. Every other person had to have a license to hunt game other than rabbits outside of his own township.

In 1909, Mr. Sweeney reported he had put out $12,000 worth of Hungarian partridges with which he proposed to stock the game preserves. He had put out 1,500 birds of different kinds in 1908. In 1909 the legislature established an open season on waterfowl from September 1 to April 15, and placed a closed season on prairie chickens for six years. The $7,500 appropriation was discontinued but left the Commissioner's salary at $1,200 with $800 for expenses.

Mr. Sweeney encouraged sportsmen of the state by advocating fish propagation. Through the influence of his department the Marion County Game and Fish Protective Association was formed and they succeeded in rearing smallmouth bass in ponds. However, their attempt to create a separate Fish Commission failed to pass the legislature.

In 1910, Mr. Sweeney was succeeded by Mr. George W. Miles of Syracuse, who was appointed by Governor Thomas R. Marshall. In 1911, Mr. Miles advocated a combined hunting and fishing license but the bill was not passed until the 1913 session.

Mr. Miles died in December of 1914 and was succeeded by Mr. Eugene C. Shireman, Indianapolis, after his appointment by Governor Samuel M. Ralston. In 1919, the office of the Commissioner of Fish and Game was abolished and the Division of Fish and Game was placed under the Indiana Department of Conservation.

It is obvious that the first efforts toward fish and wildlife conservation in the state were directed toward legal protection. Artificial propagation and stocking of fish and game were also thought to be very important in the original attempts to bring back the disappearing wildlife. Some of these rather fruitless efforts have persisted throughout the years in spite of enormous costs and failures to increase our native game. For example, the ring-necked pheasant has been stocked in every county of the state since 1900—yet, it has failed to become established except in some of the northern counties. Recent investigations indicate that much of Indiana is not climatically suited for pheasants.

It has long been known from the work in fisheries research that most of our water areas are over-stocked and over-populated so that there is insufficient food to permit our fishes to grow normally. But the traditional notion of replenishing the supply thought to have been reduced from over-fishing persists in many minds even today.

Fox hunts, crow control contests, bounties on hawks and owls, and general warfare against other so-called predators continues on an intermittent scale in numerous localities of the state. Studies in other states, notably Michigan, have revealed that these methods have had little effect on predator populations over the years.

The art of game management has matured in the past two decades to a definite science. It is the function of the game manager to determine what factors are extant in the environment that benefit or decimate wild game. He must know something of the habits, life cycle, distribution, and population densities of various kinds of game. When all these facts are known the game manager can manipulate controls to improve game habitat. While legal protection of game has served a useful purpose it must be regarded as a temporary expedient. The key to modern game management is improvement and control of the habitat.

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The Teaching of Plant Physiology at Purdue in the Nineteenth Century

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The first issue of "The Purdue University Register" was for the academic year of 1874-75 (1). Some thirteen courses in botany were listed as taught by John Hussey, professor of botany and horticulture. These courses ranged from 2 hours of Economic Botany to 10 hours of "Cryptogamic Botany and Work in the Laboratory." Plant physiology was not overlooked, for one 5-hour course was entitled "Physiological and Structural Botany" and another was called "Experiments in Fertilization of Plants".

Something about the method of teaching botany is included in the catalog section devoted to "Natural History". It reads "The instruction in Botany will embrace all the principal branches of this science. After three terms of descriptive and systematic Botany, the student will be expected to do laboratory work, making use of the microscope in Cryptogamic Botany and the study of the physiology of plants; proceeding to experiments in fertilization and to special topics. Herbarium work will be required throughout the entire course."

This account also contains a list of "books of reference" which includes "Wood's, Gray's, Youman's, Greene's, and Chapman's textbooks on botany," as well as "Henslow's Botanical Charts," and the "Prodromus" of DeCandole. Reference journals kept "in the Reading Room" included "The Gardener's Monthly" and "The American Naturalist".

In the second year (1875-76) "The Annual Circular of Purdue University" (2) had this to say about the course dealing with plant physiology: "Structural and Physiological Botany, same as in the general course, with the addition of the more recondite facts and principles, including the character and relations of parts of seeds, morphology, facts and methods of fertilization, origin of tissues, relations of plants to animals, species, etc."

These descriptions continued to apply over a period of six years and suggest that the courses were taught from year to year in much the same manner during Professor Hussey's tenure.

The "Annual Register" for 1880-81 (3) carries the information that Professor Hussey had resigned and that his successor was "Charles R. Barnes, A.M., Instructor in Botany, Zoology, and Geology". As might be expected, some changes occurred in the catalog description of Barnes' courses in botany. We find: "The second term is devoted to Physiological Botany, including the subjects of food, assimilation, and metastases, growth, fertilization, influence of light and temperature, movements, etc." This course was listed as "Physiological Botany, with experiments and laboratory work."

In 1881-82 advanced work in plant physiology was offered and the writing of a thesis indicated. "The remainder of the term will be devoted to the study of advanced 'Physiological Botany,' with class experiments and laboratory work." And again: "The student will be permitted to select some special plant or groups of plants which he will study carefully, embodying the results of his investigation in a thesis."

The catalog for the following year indicates that Charles R. Barnes was promoted to the rank of professor. A published list of "Handbooks" for students of biology included: "Lessons and Manual of Botany" by Gray, and "Botany" by Bessey. This catalog also lists "Advanced Physiology, 7 weeks" and "Preparation of Thesis, 10 weeks".

The Tenth Annual Register of Purdue University was for the years 1883-1884. Charles R. Barnes is listed as "Professor of Botany, Zoology, and Geology". Under the heading "School of Science-Botany" the following statements appear: "The study of Botany in the Freshman Year is required in this school and occupies two hours daily. Students may elect it (or Zoology) during the Junior and Senior years". "Lectures upon the anatomy and physiology of plants will be given at appropriate times in connection with the laboratory work".

This brief description suggests that laboratory work constituted a basic part of the course and that emphasis was placed, by means of lectures, upon the study of plant anatomy and physiology.

Opportunity again was given for more advanced undergraduate work in plant physiology including the writing of a thesis. This fact is stated under the heading: "Elective Course—Junior Year."

"In the latter half of the year, work will be assigned in organogeny, embryology and physiology. During the senior year students will devote themselves to original work, upon which, at the close of the year, they will present a thesis".

In the "Annual Register" for the academic year 1885-1886 a course for eight hours per week in "vegetable physiology" is briefly described for the second term. "A laboratory course in experimental Vegetable Physiology, with lectures for this. The preceding course in Histology (offered the first term) is indispensable."

Again, advanced work in plant physiology was possible. In the senior year 35 weeks of botany, eight hours per week could be had. The catalog states that the character of the work was optional with the student and that "the instruction is chiefly personal". This was the year that Professor Barnes was listed as "out on leave of absence".

The following year (1886-87) Professor Barnes returned with a PhD degree but stayed only one more year. The junior-year course in "experimental Vegetable Physiology" was again offered, this time "a laboratory course . . . with reference readings".

Professor Barnes' successor was Joseph C. Arthur who lived a long and productive life resulting in publications spread over more than half a century (4). The university catalog for the period 1887-89 lists Dr. Arthur as: "Professor of Botany—after Jan. 1, 1888 Professor of Vegetable Physiology and Pathology".

The junior-year course in "Vegetable Physiology" was continued by Dr. Arthur under the following description: "The subjects of Nutrition, Growth, Molecular forces, Movements and Reproduction of plants are covered by lectures and laboratory work, special attention being given to the experimental verification of the chief facts of Science." This description was retained in subsequent Purdue catalogs of the nineteenth century together with the added statement—"The Laboratory is particularly well equipped for this work."

At this time a graduate program in plant physiology, as well as other biological subjects, was available for the M.S. degree. The Purdue "Register" for 1888-90 under the heading of post graduate courses in biology states: "One or more topics will be assigned as subjects for original investigation, in which it will be necessary to determine the structure, development or life history of some plant or animal, or trace the explanation of some phenomenon of growth, together with the history of the subject as treated by other investigators. A knowledge of French and German will be specially serviceable in this course."

"The general study of some department of Biology will be required in addition to the above."

Thus we see that the graduate program included original research work and a study of the literature pertaining to a particular problem. Such a study was obviously to include French and German publications. In addition, a broad knowledge of some subdivision of Biology was required.

One may wonder what laboratory equipment was available at Purdue for course work and research in plant physiology. Under the heading "Apparatus and Appliances" the "Register" for 1888-90 states: "For work in vegetable physiology there is an excellent supply of glass apparatus including Sachs' double bell jars and Christiani's poroscope. Of imported apparatus, the following may be mentioned: "Wortmann's clinostat, Pfeffer's and Vöchting's dynamometers and Englemann's gas chamber. Students also have the use of some of the apparatus belonging to the Botanical Department of the Experiment Station, including Pfeiffer's warm case for the microscope, made by Zeiss, with Moitessier's gas-pressure regulator, Israel's warm stage, ovens with thermo-regulators and appliances for working glass".

Such a list admirably supports Dr. Arthur's statement, previously noted, relative to facilities for work in plant physiology, namely that "the laboratory is particularly well equipped for this work." This applied to an era in which the physiology of plants was attacked by using entire plants or organs in contrast to much modern work in which plant parts are fragmented into microscopic bits before study.

The specific functions of the foregoing apparatus are stated in the 1890-92 "Register". We read: "Wortmann's clinostat: For the study of the relation of gravity and light to changes in the direction of growth, made by Ungerer of Strassburg; auxanometer: For recording the growth of plants. The clock for electrical release and the pulleys for magnifying the movement due to growth were made by Albrecht of Tübingen, while the recording cylinder was made in the University shops. Pfeffer's and Vöchting's Dynamometers: For determining the pressure exerted by growing organs."

High caliber botanical journals publishing physiological papers were now available in libraries upon the Purdue campus. These included the "Annals of Botany", "Berichte der deutschen botanische Geselschaft," "Botanical Gazette", "Botanisches Centralblatt", and "Botanische Zeitung". In both equipment and published literature, Purdue University thus had drawn heavily upon the accomplishments of the active group of German plant physiologists of the latter nineteenth century. Mention also should be made of additional physiological apparatus designed and built under the direction of Dr. Arthur (5).

A noteworthy addition to the Purdue staff is listed in the 1891-93 "Register". He was Daniel T. McDougal, Assistant Instructor in Biology. McDougal held a bachelor's degree from DePauw, later studied in Germany, and eventually took his doctorate at Purdue with a thesis (6) in plant physiology.

Greenhouse facilities for advanced work in plant physiology and other botanical subjects are described in the 1893-94 "Register". "A greenhouse strictly for experimental work, is connected with the botanical laboratory of the experiment station. Students pursuing advanced work in botany make use of this building to some extent in experimental research. The ventilation and heating of the building are under good control, and electrical and mechanical apparatus assist in the carrying on of interesting instruction concerning the growth of plants."

To this was added a supplementary description the following year: "A glass vegetation house, used for protecting plants growing under control conditions in metal pots, is also a feature of this department of the experiment station."

At the close of the nineteenth century we find, therefore, the work in plant physiology housed in the agricultural experiment station. Under the heading "Laboratory of Vegetable Physiology", Dr. Arthur stated (Annual Register for 1896-97): "The work in vegetable physiology and ecology and in cryptogamic botany is provided with quarters in the Experiment Station building. The general laboratory is especially well fitted with convenient water and gas connections, desks and cases. A door opens directly into the greenhouse in which part of the experimental work is carried on. A special laboratory adjoins the general laboratory which is devoted entirely to the use of students and is conveniently fitted for a variety of work."

To the previous catalog descriptions of the available physiological apparatus was added, at the turn of the century, equipment emphasizing the growing use of quantitative and chemical techniques—"Several Springer torsion balances, together with a barometer and other pieces of the more usual chemical and physical apparatus are available" (1900-1901 "Annual Register").

Thus we find a sustained program in the teaching of plant physiology during the first quarter of a century of Purdue University's existence. The importance of laboratory work was early recognized and opportunity was given students for original work. Professor Hussey deserves credit for originating the work and Professors Barnes and Arthur for so ably carrying it forward. Perhaps the academic climax in this program and era was the granting of the degree "Doctor of Philosophy" to Daniel T. MacDougal in 1897 on his thesis entitled "The Curvature of Roots". This was the second PhD degree granted by Purdue University and the first in the biological sciences.

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Early Weather Records in Indiana

LAWRENCE A. SCHAAL[1]

The first weather observers in Indiana were a hardy group of people who believed that an analysis of rainfall, temperature, wind and air pressure data would further agriculture, improve long and short range weather forecasting and further medical climatology. In the remarks which follow an attempt is made to piece together in history the collection of early weather data in Indiana

In the eighteen hundreds the motives that stimulated man to record the elements of the atmosphere were essentially like those of today. At army forts the doctor often assumed responsibility of recording temperatures and rainfall. It was thought at the time that typhoid fever and other diseases were caused by the weather. The former has been proven false but there still exists a relationship between such ailments as the common cold and the weather. Perhaps 50 years from now the cause and effect relationships between illnesses such as hay fever and the weather will be determined.

In the eighteen hundreds as well as today the interest in recording the weather was related to prognosticating. The long range forecast was a popular speculation in the early days much as it is at the present time. Professor W. H. Ragan of DePauw University in his Meteorological Summary of March 1885 made a forecast of the next winter. It read, "From such study as we have been able to make with the incomplete and recent data in our hands, we feel almost justified in expecting, with some confidence, an unusually mild winter for 1885-86. This, viewed as a prediction, must be received with extreme caution, for we have no certain means of knowing how it will turn out. The expectation is based principally on the assumption that constant cause must produce constant effect, and that whatever the force that has given us the three past cold winters it was abnormal, and the reaction will carry to the other extreme to restore the equilibrium." In the same report, "This fragmentary review also shows that our weather conditions are dependent on forces and currents set in motion far outside the boundaries of the State."

In those days there was a growing belief that much weather in Indiana moved from the west to the east which is of common knowledge to television viewers today. In June 1885, Professor Ragan thought this to be true and ventured a statement of explanation. Quote, "An investigation was set on foot on the hypothesis that areas of excessive rainfall move eastward. A crude examination of the rain records of Leavenworth and Indianapolis gives 58 to 49 in favor of the correctness of the hypothesis. The ground being left saturated after a "wet spell", vapor would be thrown into the air, rapidly carried east by the general movement, and condensed eastward of the "wet" area with unusual copiousness."

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Weather records of the 1800's are not numerous. Weather data was often kept in diaries or with some other method of recording data and thus were lost. No doubt some of the first settlers kept rainfall records somewhat crudely. After all it was important to their agriculture and had to be considered in determining the best place to settle and to cultivate the land.

In the early eighteen hundreds very few weather stations existed in Indiana and communications were poor. There was no known state wide summarization of data from various stations in Indiana on a monthly basis until 1882. In those days there were several groups at the national level interested in obtaining weather reports. Observers for the Smithsonian Institute were known as volunteer observers. In this period the Surgeon General's Office and the Signal Office aided in collecting weather data. At least two networks existed in Indiana. Monthly summaries of temperature and rainfall in the state were duplicated to some extent in the eighteen eighties.

The Indiana State Weather Service was located at Indianapolis in June 1882. From November 1883 to at least 1886 the Indiana State Weather Service was located at Purdue University. H. A. Huston was the Director. The publication, Monthly Meteorological Summary from Stations of the Indiana Weather Service, apparently began in September 1884. For a short period from December 1886 to August 1888 the organization was called "Indiana Signal Service" rather than Indiana Weather Service. It is interesting to note that cooperators or sponsors were the Indianapolis Board of Trade and five railroads besides the U. S. Signal Service and Purdue University.

At about the same time Professor W. H. Ragan at DePauw University published weather data collected from Indiana *Volunteer* Weather Observers. His monthly reports are available for November 1884 to September 1886. These were published in cooperation with the Chief Signal Officer, U. S. A. beginning November 1885.

The monthly summaries of the two services used some of the same weather stations. Some stations had longer weather records than we are able to find today. Much of this data is lost. This was true even in 1872 when Charles G. Boerner, Observer at Vevay, reported in the 14th Annual Report of the Indiana State Board of Agriculture than an extensive log of weather data had been taken in his community in the early 1800's but that it had been lost.

The longest and still continuing weather record in Indiana is the one which was begun in November 1864 by Mr. Boerner at Vevay in Switzerland County. He recorded weather data until December 1899. His daughter, Miss Frederica Boerner, continued the good work to September 30, 1921. Apparently the instruments remained in approximately the same location for this entire period.

Mr. Boerner was a personal acquaintance of Cleveland Abbe, a well known meterologist at that time. The record continues at Dam 39 near Markland which is 6.4 miles northeast of the old site in Vevay on Pearl Street, 4 blocks from the Ohio River.

Moving backwards in time we find that northern Indiana is the location of several old weather records. At Logansport in Cass County, the weather records begin July 1854. T. B. Helm was the observer from 1860 to 1888. Weather data is fragmentary in very early years, beginning in July 1864 at Collegeville, in March 1849 at LaPorte and at South Bend in 1862. The large cities as we know them today were not first with early weather observations.

At Spiceland in Henry County monthly rainfall data is available beginning in May of 1863 to May of 1890. The observer made the remark in December of 1889 that it was the only December in 36 years without snow. So it appears that these records began in 1853 or ten years earlier than those that are published.

An old weather record, which was made at Richmond, Indiana, is deposited in the National Archives at Washington, D. C. Rainfall data is available for the period of January 1852 to August 1868. The record resumes in 1883 and it is unbroken except for a period of May 1892 through December of 1895.

The first well organized and lengthy weather records of Indiana are those recorded by the early settlers at New Harmony. Temperature and rainfall data is nearly unbroken from June 1853 to March 1883. The first very complete weather records were recorded by these people, however, in the period of January 1, 1826 to January 31, 1829. The observers were David Dale Owen, Stedman Whitwell, Gerald Troost, and John Chapplesmith. The observations included the direction and force of the wind, state of the weather, types of clouds and the usual, rainfall and temperature data. Three to nine observations were taken daily. A conical shaped rain gauge was used which was made in London in 1824. It is claimed that the conical rain gauge was the first in the midwest and the second in America; the other being at Washington, D. C.

The number of weather observers in Indiana increased rather rapidly beginning in the 1860's. No attempt has been made to mention all observers or stations beginning at that time or later. Population growth and greater awareness of the vicissitudes of climate and their importance accompanied the growth of the weather observing network in later years in Indiana.

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History of Paleobotany in Indiana

JAMES E. CANRIGHT, Indiana University

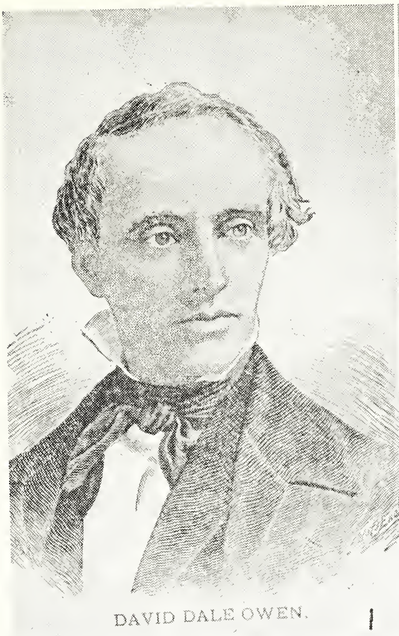
The first known report of the discovery of fossil plants in Indiana was that in 1843 by the first State Geologist, Dr. David Dale Owen (11). Because the current year marks the Sesquicentennial of David Owen's birth (1807), it seems only fitting and proper at this time to record his interests and activities in this relatively new science of paleobotany. Furthermore, any account of David Owen's geological activities must necessarily include more than a passing mention of two other men of reknown—Colonel Richard Owen, David's younger brother, and Dr. Leo Lesquereux, later known as the "Father of American Paleobotany." Richard Owen, three years junior to David, served as his geological assistant on numerous surveys throughout the middle west, and succeeded him as State Geologist of Indiana after his brother's death. Leo Lesquereux, beginning in 1854, was hired by David Owen as paleontological assistant for the geology surveys and description of the coal floras of Kentucky, Indiana, and Arkansas.

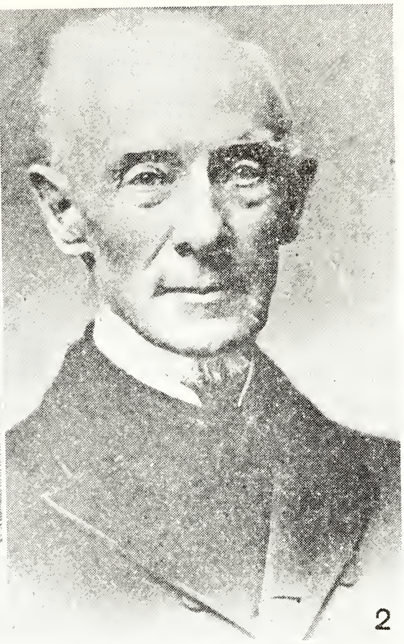
David and Richard Owen were born in New Lanark, Scotland, sons of a wealthy mill owner, Robert Owen. In 1827, after scientific training (including majors in chemistry) in private schools in Switzerland and in Glasgow, the two brothers accompanied their father to New Harmony, the scene of his famous socialistic "experiment" on the banks of the Wabash River. After a year spent at University of London studying chemistry and geology, David returned to this country to matriculate at the Ohio Medical College at Cincinnati, from which institution he received the M.D. degree in 1835. Further geological experience was gained as an assistant in the reconnaissance of Tennessee, followed by a position which involved the classification and organization of the large mineral collection of that famous pioneer of American geology, William McClure.

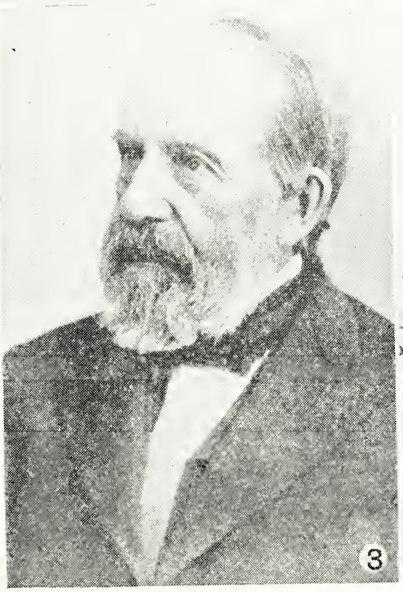
In the year 1837 David Owen was appointed to the post of Principal Geologist of Indiana (Fig. 1). The prime purpose of this position was for Owen to conduct a geological reconnaissance of the state. The governor of the state, James Whitcomb, was so impressed with the thoroughness and scientific value of Owen's report, that when Whitcomb became commissioner of the Federal Land Office in Washington the following year, he selected Dr. David Owen as the leader of a mineral survey of some 11,000 sq. miles of the Northwest Territory.

As an indication of Owen's energy and efficiency, it might be mentioned that this federal appointment did not reach him at his home in New Harmony until August 17, 1839, yet he managed to recruit, equip, and train 139 men in rapid time, so that, by his tireless efforts in the field, he managed to submit his final report to Washington less than five months later (as required by the terms of his appointment).

In 1843 David Owen discovered 20-25 casts of the trunks of fossil trees standing upright in a shale of Carboniferous age on the banks of







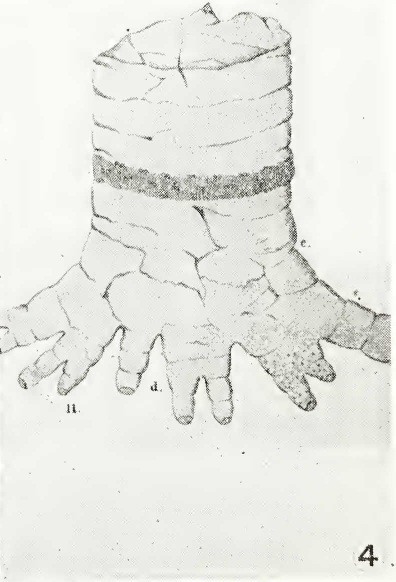


Figure 1. David Dale Owen (1807-1860), about the time of his appointment as the first State Geologist of Indiana.

Figure 2. Colonel Richard Owen (1810-1890), taken at the time of his retirement from the faculty of Indiana University.

Figure 3. Leo Lesquereux (1806-1889), taken at about age 60.

Figure 4. *Didymophyllum* (*Sigillaria*) *Owenii* Lesqx., the first fossil plant described from Indiana. This was a sandstone cast of a stump of a decorticated tree of Upper Carboniferous age. The paired scars (shown in the median band) represent aerating channels (parichnoi) which were formerly connected with similar structures in the leaves.

Big Creek, approximately twelve miles southeast of his home in New Harmony. He published two papers describing these fossil trunks (11, 12), but erroneously described them as palm trees. However, his misidentification of these trees as palms is readily forgiveable when one remembers that the formal science of paleobotany was founded only fifteen years earlier in France by Adolfe Brongniart, and that only a smattering of paleobotanical literature had found its way to New Harmony by that time.

Owen presented one of these trunks, measuring two feet high by ten inches in diameter, to the Academy of Natural Sciences in Philadelphia (Fig. 4). At the same time his skilled painting and descriptions of the fossil trunks *in situ* were transmitted to London where they were presented by his friend, Sir Roderick Murchison, at a meeting of the British Association for the Advancement of Science. This presentation brought Owen to the attention of the "Father of Modern Geology," Sir Charles Lyell. During the course of Lyell's second trip to the Americas, he spent some time as a house guest of David Owen, and also accompanied him on a visit to the now-famous fossil tree site.

The years 1847-1852 were spent by David Owen as leader of a gigantic geological survey of more of the Northwest Territory, chiefly the area now comprising Wisconsin, Minnesota, Iowa, and parts of Illinois and Nebraska. Richard Owen, after serving as a captain of infantry in the Mexican war, assisted his brother with this survey of the Northwest, then took a position as professor of science at the Western Military Institute of Kentucky. The 638 page report of this survey was published by Congress and included some steel engravings of fossils by David Owen, the first time this method of illustration had been used for fossil specimens.

At this point, it becomes necessary to outline rather briefly the background of Leo Lesquereux, leading up to his close relationship with the Owen brothers.

Leo Lesquereux (Fig. 3) was born in 1806 at Fleurier, Switzerland, the son of an exiled French Huguenot couple. After a thorough schooling at nearby Neuchatel, young Lesquereux (at the age of twenty) took a position in Saxony as tutor in French to the family of General von Wolffskel. After a year of tutoring, Lesquereux asked the General for permission to marry his daughter, the Baroness Sophia. His request was tentatively accepted, with the proviso that he prove his ability to support his wife in the manner to which she was accustomed. Thereupon Lesquereux returned to Switzerland and won a competitive examination for the principalship of a high school. Supplementing his regular salary by tutoring after school hours, he found that he was able to earn the magnificent sum of $500 a year. In 1830 he decided this income was adequate, so returned to Saxony to marry the Baroness Sophia. A young army lieutenant named von Moltke (later to become the chief of staff of the German army) served as his best man at the wedding. Misfortune soon struck, however, for Lesquereux began to have increasing difficulty with his hearing, and was forced to resign his teaching position. In desperation he travelled to Paris for treatment by a famed ear specialist. This putative "specialist" burst his Eustachian tubes, and the resulting brain infection for a time threatened his sight. Lesquereux finally returned to Switzerland stone deaf, and never heard another sound for the rest of his life. However, he trained himself to read lips in three languages—a major accomplishment when one considers that full beards were common in those days!

As the teaching profession was now closed to him, Lesquereux was forced to join his father in his small watch factory in order to support his family. As an intellectual outlet to his menial task as a watch engraver, he read widely on botanical subjects, taking a major interest in the structure and classification of the mosses. At this time the Swiss government offered a prize for the best essay on the manner of formation and preservation of peat, and Lesquereux set out to win it. He invented an instrument for sampling peat bogs, and spent all his spare time investigating under a microscope the results of his peat-drilling experiments. Not only did he win the prize handily, but he came under the favorable notice of an illustrious member of the prize committee, Louis Agassiz, professor of natural history at the Academy of Neuchatel. Lesquereux was the first to determine the true causes of peat formation, thus unconsciously, perhaps, making the first step in the science of coal geology. After a brief political appointment as "Director of Peat Bogs" in Switzerland, he was commissioned by the king of Prussia to investigate peat bogs in northern Europe. This position permitted him to travel widely and to meet most of the best-known geologists and paleontologists in their laboratories.

In 1845, at the urging of Agassiz, who was now teaching at Harvard University, Lesquereux and his family emigrated to the United States. His first employment in this country was to classify plants collected by Professor Agassiz on his Lake Superior expedition. Next, William Sullivant, America's leading bryologist, asked Lesquereux to collaborate with him, and they published two editions of "Musci Exsiccati Americani," an authoritative work on American mosses.

It is interesting to note that Lesquereux had no direct association with the science of paleobotany per se until 1851, when (at the age of 45) he was employed by the Pennsylvania Geology Survey to study the fossil coal flora of that state. The resulting "Coal Flora of Pennsylvania, etc.", published in three volumes and an atlas (8, 9), still remains the most outstanding publication on this subject in the western hemisphere.

David Owen was appointed the first State Geologist of Kentucky in 1854. Having become acquainted with the fame of Lesquereux's work with the Pennsylvania Survey, Owen wasted no time in hiring him as his paleontological assistant. After four years together on the Kentucky Survey, David Owen was appointed State Geologist of Arkansas, and he took Lesquereux with him to study the coal flora of that region. In 1859 David Owen was reappointed State Geologist of Indiana. In failing health at that time, Owen accepted with the understanding that his brother, Richard, and Leo Lesquereux were to conduct the actual field work in Indiana. On November 13, 1860, David Owen died, and his brother succeeded him as State Geologist. The following year the Indiana state legislature passed a law which still exists today—the

State Geologist is to be made a member of the Indiana University faculty. Thus, Richard Owen (Fig. 2) became the first professor of geology at Indiana University.

In Owen's "Report of a Geological Reconnaissance in Indiana" is included Lesquereux's description of the fossil plants associated with the various coal seams of this state (6). By this time Lesquereux was the acknowledged authority in this specialized field, and consequently his services were widely sought by state, federal, and private agencies. During the next two decades a list of his more important publications of interest to paleobotanists includes: "Fossil Coal Flora of Arkansas", "Fossil Plants of Illinois", "Fossil Plants from the Tertiary of Mississippi", "The Cretaceous and Tertiary Floras of the Western Territories", and "Species of Fossil Marine Plants from the Carboniferous Measures" (7). He was the first elected member of the National Academy of Sciences and the recipient of many honors, both here and abroad.

In 1884, John Collet, the 4th State Geologist of Indiana, commissioned Lesquereux to write a sort of textbook for inclusion in his annual report. This text was entitled "Principles of Paleozoic Botany" and included descriptions and illustrations of the most common fossil plants (10). In his introduction Collet stated, "It will enable everyone to study and analyze the beautiful specimens of fossil plants abundantly found in our Coal Measures." Unfortunately, his enthusiasm has been shared by too few in this state. After the completion of this text in 1884, Lesquereux was too old (78) to carry on any further field work. Nevertheless, he still continued to identify numerous fossil plants which were sent to his Columbus, Ohio, laboratory right up to the time of his death five years later.

In 1896, David White, a young paleobotanist (who later became Director of the U. S. Geological Survey), described nineteen specimens of fossil plants from the whetstone quarries of Orange County, Indiana (14). Utilizing this flora he was able to correlate Indiana's Whetstone Beds with rocks and floras of mid-Pottsville age in southern Pennsylvania. This was the first example of stratigraphic correlation of widely-separated areas (and different coal basins) by means of plant fossils.

George H. Ashley in 1899 wrote a very comprehensive report on the coal deposits of Indiana (1), which included not only a list of the fossil plants of Carboniferous age previously described from Indiana, but also the known collecting sites for fossil plants in twenty Indiana counties underlain by coal-bearing rocks. Unfortunately, however, most of these collecting sites are no longer of any value due to erosional forces and man's activities since that time.

After the turn of the century, interest in paleobotany in Indiana seemed to go into a period of decline for the next fifty years. Some exceptions which might be mentioned are: T. F. Jackson's reports (4, 5) on some rather poorly-preserved fossil plants from Monroe County, and W. S. Benninghoff's description (2) of a coal ball flora from a mine near Petersburg, Pike County.

Within the past five years paleobotanical interest in Indiana has been reawakened, as witnessed by the appearance of papers by Guennel (3), Wood and Canright (15), and Shutts and Canright (13). It is hoped that this trend will be continued—following the early trails blazed by the illustrious Owen brothers and their good friend, Leo Lesquereux, the "Father of American Paleobotany."

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MATHEMATICS

Irving Burr, Purdue University, was elected chairman for 1958

ABSTRACTS

Class Administration in Courses Using a Textbook. G. H. Graves, Valparaiso University.—Purposes of the class meeting are: to further the student's mastery of his material and to increase his ability to gain results from study. Hence the first order of business is to answer his questions. Other students should ordinarily do this. Sarcasm is never permitted but plain speaking may be necessary, such as, "The teacher has no responsibility for the student who does not study." In courses where a textbook is used, there should be no lectures and note taking should be discouraged as it detracts from the mental concentration required to follow a discussion. For testing and records, seat work has many advantages which home work handed in and board work do not.

The Mathematics of the Future. P. D. Edwards and Charles Brumfiel, Ball State Teachers College.—Professor Edwards emphasized the increasing importance of having high school teachers of mathematics who are much more thoroughly trained in advanced mathematics than was considered necessary a relatively few years ago. This applies not only to the traditional topics needed by the engineer and physical scientist but also to the needs of workers in other fields. It is felt that very definite improvements in the preparation may be made by drastic changes in the content of high school mathematics. Professor Brumfiel made a progress report on an experimental program now being supervised by Ball State which was made possible by a grant of the National Science Foundation.

A Characterization of N–adic Equivalence Relations. J. L. Lawrence, Wabash College.—The concepts of symmetry, transitivity, composition, and equivalence associated with dyadic relations are generalized to apply to the n–adic case. In the generalized scheme, symmetry and transitivity persists as a necessary and sufficient condition for an n–adic relation to be an equivalence relation. Furthermore, as in the dyadic case, a n-adic relation is transitive if and only if the relation contains the composition of the relation with itself.

The Concept of Surface Integral. Lincoln H. Turner, Purdue University.—A continuous parametric surface (T, A) is a continuous mapping T from a subset A of E_2 into three space E_3, $p = T(w)$, $w = (u,v) \varepsilon A$, $p = (x,y,z) \varepsilon E_3$. The usual definition of area in terms of the Jacobians of the mapping is inadequate in modern analysis. An adequate definition was given by Lebesgue in terms of sequences of polyhedral mappings which approach the original mapping. When the area is finite, four measures φ, V_1, V_2, V_3 may be defined by means of these sequences on a certain ring of Borel subsets of A such that V_1, V_2, V_3 are absolutely continuous with respect to φ. The Radon-Nikodym derivatives $\theta_1(w) = \frac{dV_1}{d\varphi}$, $\theta_2(w) = \frac{dV_2}{d\varphi}$, $\theta_3(w) = \frac{dV_3}{\varphi}$ exist and satisfy $\theta_1^2 + \theta_2^2 + \theta_3 = 1$ a.e. (φ). The vector $\theta(w) = (\theta_1, \theta_2, \theta_3)$ may be thought of as the direction normal to the surface (T,A) at T(w). Then if $D = \{\theta_1, \theta_2, \theta_3): \theta_1^2 + \theta_2^2 + \theta_3^2 = 1\}$ and $f(x,y,z, \theta_1, \theta_2, \theta_3)$ is any function which is Borel measurable and bounded on T(A)x D, the integral

$$H(T,A,f) = (A)\int f(T(w), \theta(w))\, d\varphi$$

exists and is the integral of f over (T,A).

Periodic Solutions of Nonlinear Differential Equations. W. R. FULLER, Purdue University.—The present paper is expository in nature. In it are indicated some types of nonlinear differential equations or systems of such equations, for which existence theorems for period solutions have been studied. This includes systems containing a small parameter, ε, which for $\varepsilon = 0$ have periodic solutions. In particular the study of systems of the form $x + \sigma^2 x = \varepsilon f(x,x,t;\varepsilon)$ where $\sigma^2 x$ and f are n-vectors has been very fruitfully attached by a method of L. Cesari which has been applied to a wide class of problems by Cesari, Hale, Gambill, Bailey and the author.

Localization Experiment for Teaching Geometry. A. D. HUMMEL, Ball State Teachers College.—The calculation of the distance between two points from their x, y, and z coordinates is well known. A method of determining these coordinates of points within a body by means of X-rays is reviewed. Projected images of scales are used as measuring sticks in two radiographs. The source of X-rays has different positions for the two radiographs. Elementary geometry is used to compute the coordinates of any point appearing in both radiographs. In the experiment described for teaching, a small source of visible light is substituted for the X-ray source. Data obtained from shadows is used to calculate the length of an object. Verification of the result by direct measurement should strengthen the student's faith in geometry.

Undergraduate Curricula—Some Brave Experiments and Cogent Lessons. ARNOLD E. ROSS, University of Notre Dame.—There are many, all too many critical problems which confront one in the task of implementing an effective undergraduate program in mathematics. Today such a program must not only appeal to the people who have traditionally relied upon mathematical tools, but it must also appeal to the users of new mathematics most of whom come from the humanities, from commerce, and from the "preprofessional" groups. The novelty of the new undergraduate curriculum lies not only in the new content but also in the growing recognition that mathematical manipulative skills alone do not develop the capacity for intelligent application nor do these skills alone justify considering mathematics as one of the liberal arts.

To design a proper blending of the new and the old, of ideas and of skills, and to make this blend accessible to the very young brings us close to the fundamental questions in the art of communication. It is the purpose of this short talk to discuss and to illustrate some of these questions.

It should go without saying, but it will bear much repeating, that a knowledgeable, imaginative, and resourceful teacher is still the key to the success of any enlightened curriculum. This observation applies to the teaching of all mathematics, even the so called "very elementary mathematics". Thus it is vital that not only the teaching of the undergraduate should reflect faithfully a sound outlook on both teaching and mathematics, but that this should hold also for a Mathematics Teacher Training Program (such as we have undertaken at Notre Dame for example).

On the Inter-relationship of Applications and Mathematical Research. KAJ L. NIELSEN, U. S. Naval Avionics Facility, Indianapolis, Indiana.—There seems to be no limit to the application of mathematics to contemporary non-mathematical fields. To present a complete survey of the utilization of mathematical research in engineering, economics, production, sociology, psychology, medicine, etc., would be quite beyond the scope of this paper. We shall therefore limit this discussion to the inter-relationship of mathematical research with some technological developments, electronic calculating machines and the philosophy of education. The mathematician's role in industry; industry's utilization of mathematicians; the development of new mathematics and the need for closer unity between user, producers and educators of mathematical research is discussed from the author's point of view.

PHYSICS

Chairman: MALCOLM CORRELL, DePauw University

LEWIS SALTER, Wabash College, was elected chairman for 1958

ABSTRACTS

Magnetic Fields in the Solar Atmosphere.[1] MALCOLM CORRELL, DePauw University.—The various ways of obtaining knowledge about magnetic fields in the solar atmosphere have been reviewed. One of the most promising is to measure a composite map of the prominence trajectories that occur over an active region during a period of time. This report covers an analysis of the well-observed prominence of CMP April 13, 1950 at N 13° heliographic latitude. If a magnetic dipole were buried 0.03 solar radii beneath the solar surface, with its axis tilted ± 50° from the plane of projection, the trajectories and the lines of force nicely concurred. There is evidence that a radio noise storm at meter wavelengths was associated with the region and was emitted parallel to the dipole axis. A geomagnetic disturbance was so timed that it could have resulted from solar particles emitted parallel to the dipole axis.

Experimental Comparison of A-C Powered Diode and Hydrogen Ion Gauge Circuits for Leak Detection in a High Vacuum System. ROBERT H. L. HOWE, Eli Lilly and Company.—The efficiency of an a-c powered diode circuit and an a-c powered hydrogen ion gauge circuit for leak detection in a high vacuum system was compared experimentally. The circuits used are modified by the author and P. L. Hartman from those suggested by R. B. Nelson and R. L. Sproull respectively. Experiments were conducted at Cornell University Department of Physics.

In this work the vacuum system employed consists of: (1) a mercury diffusion pump, backed by a mechanical fore pump, (2) a mercury cut-off with shunt arms of different diameters, (3) a pre-calibrated McLeod Gauge, (4) a liquid air trap, and (5) a glass vessel which is provided with connections to a glass tubing serving as a part of the variable leak to be detected, and also to the diode and the hydrogen ion gauge. The total volume of system was approximately 2.20 liters.

The hydrogen ion gauge tube was "R.C.A. 1945". It was sealed to the vacuum system and its terminals were connected to the detector circuit.

The diode tube was "R.C.A. 1949" which was also employed as an ionization gauge tube for measuring the "size" of leakage in the vacuum system. Its terminals were connected to the circuit.

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[1] This research was made possible through a grant from the National Science Foundation.

When the a-c powered diode leak detector circuit was in operation, hydrogen and then oxygen (at 5 liters per min.) were applied over the general location of the leak and the steady emission current change (due to the contamination of the filament by the gas) from that when there was no leak observed. Different sizes of leaks were provided and detection results obtained.

With the hydrogen ion gauge circuit on for leak detection, only hydrogen (at 5 liters/min.) was applied over the leak. The change in ion current indicating the passage of hydrogen through the particular size of leak was observed. Different sizes of leaks were provided and detection results obtained.

The a-c powered ionization gauge circuit using the "R.C.A. 1949" tube was employed to measure the rate (size) of leakage, pressure in the vacuum system being determined from the pre-calibrated McLeod Gauge and the rate being calculated from the equation, $Q = \triangle PV/t$. Q is the rate of leakage in micron-liters per hour, $\triangle p$ the change of pressure in microns Hg, V the predetermined volume of the vacuum system, and t the time interval in hours.

Experimental results indicated that the diode circuit could detect leaks as small as 0.010 micron-liters/hour and the hydrogen ion gauge could detect leaks as small as 0.10 micron-liters/hour, the former being almost ten times more sensitive than the latter. However, the latter is relatively independent of leak size and time-saving to operate. With proper modifications, both the a-c powered diode and hydrogen ion gauge circuits would be very efficient for leak detection in a high vacuum system.

Absolute Measurement of Beta-Activities Using Sources of Saturation Thickness. H. FISCHBECK, Indiana University.—A method will be described which makes it possible to calculate the specific activity of sources of saturation thickness to an accuracy within 5%, if the number of emitted Beta-particles is measured in 2π—geometry. The calculation makes use of the practical range of electrons in Al and a factor, a, which depends surprisingly little on the beta-energy E and the atomic number Z of the source material. The factor, a, and its dependence on E and Z has been studied experimentally over a wide range. The method described can be used on almost all beta-emitters, where the decay scheme and spectrum is known.

Alpha Particle Irradiation of Germanium at 4.2°K.[1] G. W. GOBELI and K. LARK-HOROVITZ, Purdue University.—Employing a sealed polonium-210 alpha-particle source with an effective energy of 3.7 Mev, degenerate n-type and p-type germanium samples were irradiated at 4.2°K. Samples held for long periods at 4.2°K following irradiation showed no thermal recovery. Carrier concentration changes were linear with the flux and removal rates calculated from Hall coefficient give 2.84×10^4 electrons/alpha particle-cm and 0.662×10^4 holes/alpha particle-cm respectively for n-type and p-type samples. A calculation of the lattice displacements, employing a displacement threshold energy of 30 ev, yields 2.79×10^4 displacements/alpha particle-cm. Isochronal annealing indicates no measurable thermal recovery occurs below 22°K. After warming to 78°K it was found that thermal recovery in n-type and p-type samples was essentially the same, (25% and 22%). Resistivity measurements taken while the samples warmed to 78°K indicate two distinct regions of thermal recovery, with maximum rates occurring near 32°K and 66°K. Isothermal annealing indicates the lower temperature process follows a first order reaction with an activation energy of about .02 ev. The higher temperature process does not yield to simple analysis.

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[1] Work supported by U.S.S.C.

Minority Carrier Lifetime in Indium Antimonide.[1] R. A. LAFF and H. Y. FAN, Purdue University.—The lifetime of excess carriers in single crystal specimens of pure p-type InSb has been measured in the temperature range from 84°K to 180°K. The lifetime is determined from either the infrared light photoconductivity or from the diffusion length of the optically excited excess carriers as measured in the photoelectromagnetic effect. In the temperature range from 130°K to 180°K, both methods are in agreement, and the lifetime decreases exponentially with decreasing temperature. Below 130° K, the lifetime as measured by photoconductivity rises, while the PEM effect indicates a decreasing lifetime. Drift mobility measurements show that below 130° K there is trapping of minority carriers. The delay time between the collector signal and the emitter pulse is about 70 times the expected transit time.

(d,p) Reactions in Lead. H. J. MARTIN, Indiana University.—Angular distributions, Q-values, and absolute cross-sections have been measured for (d,p) reactions leading to states in Pb^{207}, Pb^{208}, and Pb^{209}. Nearly all of the angular distributions have peaks between 60 and 120 degrees and fall off rapidly at forward angles. The distribution for the ground and first excited states of Pb^{207} and for the ground state of Pb^{208}, all involving a neutron angular momentum transfer $1_n = 1$, are very similar. This similarity will be used to allow comparison with True and Ford's theoretical calculations of the Pb^{206} states.

Information Handling and Numerical Machine Control. H. B. THOMPSON, General Electric Company, Evendale, Ohio.—The need for improved means of handling vast quantities of information for human and machine use has become obvious in the last 10 years. Considerable work has been done to meet this need. Mechanical data handling is common; coding has been started for handling library work, electronic component procurement, and translation.

Defense equipment has become more complicated and more expensive to the point that lead time and human error are of extreme importance. This means that mechanical handling of information for machine tools is virtually a necessity. Several machine tools are in production and use which control position for drilling, boring, etc. A few contour milling machines have been made and several are between the design stage and the finished product.

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[1] Supported by an Office of Naval Research Contract.

Both of these uses of mechanical information handling are going to have a profound influence on our way of life. However, numerical control of machine tools is a present reality and has arrived ahead of educational facilities to prepare the various areas (drafting, planning, maintenance, and operating) for them. This situation needs to be rectified as soon as possible.

Resistance Anomalies in Binary Alloys at Low Temperatures. A. N. GERRITSEN, Purdue University.—A short survey will be given about the anomalous resistance effects at temperatures below 20°K in dilute alloys of a noble metal and a transition metal as a solute. The connection between these resistance anomalies and other properties will be indicated.

An Investigation of Luminescence Excited by Vacuum Ultraviolet Radiation. RICHARD L. CONKLIN (introduced by R. E. MARTIN), Hanover College.—A vacuum spectrograph and light sources for spectral investigations in the extreme ultraviolet (100-1500 A) are described briefly. A survey of the responses of several representative crystal phosphors to these wavelengths has been made, and certain types have been found to increase in quantum efficiency as the exciting wavelength decreases. It is suggested that this increase may be due to one or more stages of ionization within the crystal.

Lorentz-Covariance of Commutation Relations. F. J. BELINFANTE, Purdue University.—New elementary particles call for new wave fields of which they are the quanta. Relativity theory is useful as a criterion that any acceptable field theory should satisfy. Usually it is easy to see whether the field equations of a proposed field theory are covariant or not. Many workers in field theory are satisfied with verifying the covariance of these equations under Lorentz transformations. Standard procedures are available for generalizing a Lorentz-covariant theory to a general-relativistic theory if necessary. The problem arises whether any Lorentz covariant theory can be quantized by the naive prescriptions $qp \pm pq = (ih/2\pi)\underline{1}$. Although some authors have maintained this, it is well known that actually this is not the case. The question then is how one should quantize, and how one can prove that those quantum rules to be imposed will show relativistic covariance. A second question is whether Tomonaga-Schwinger's method of the interaction representation is applicable to such theories. For some types of field theories both questions have been answered in the positive. We have been investigating cases where we have a definite answer to the first question, but the question about the interaction representation which is of paramount importance has been answered only for individual cases and no "general" proof is known, contrary to statements by various authors.

The Measurement and Shapes of Beta Spectra. JOSEPH H. HAMILTON, Indiana University.—With the realization of parity non-conservation, the information that is obtainable from the detailed study of beta spectra must be re-examined. Whatever form the new theory takes, it must explain the shapes of beta spectra. For shapes to be meaningful, all possible sources of instrumental distortion of spectral shapes must be considered. The problem of minimizing distortions in magnetic spectrometer studies is presented. The beta spectrum of Pr^{143} which exhibits a non-allowed, non-unique shape is discussed. Anomalies reported in the beta spectra of In^{114}, P^{32}, Y^{90} are re-examined in light of new data on the beta spectrum of Na^{22}.

Beta Decay of Ru^{103}. R. L. ROBINSON, Indiana University.—In an earlier investigation the intense inner beta spectrum of Ru^{103} was observed to have an anomalous shape corresponding to a deficiency of electrons at low energy. This shape cannot be explained by the generally accepted theory of beta decay. Using a 4π beta-ray scintillation spectrometer, this beta group was observed in coincidence with a 495-kev gamma ray. The Fermi plot is now found to be linear down to 37 kev.

The beta spectrum in coincidence with the 610-kev gamma ray was also measured. By comparison of the total decay energies of the inner beta groups and their cascading gamma rays, it was deduced that the 610- and 495-kev gamma rays decay to the same energy level.

The measured endpoint energies of the two beta groups in coincidence with the 495- and 610-kev gamma rays were respectively 227 ± 4 and 118 ± 4 kev.

Surface Investigations in Germanium. R. BRAY and R. W. CUNNINGHAM, Purdue University.—Gold doped germanium has such a high resistivity at low temperature (approximately 10^6 ohm-cm at 80°K) that it becomes a sensitive detector of changes in surface properties. This property has been used to advantage in the study of surface conductance stimulated by light, magnetic, and electric fields. Very interesting effects are found when the surface is oxidized. When light is used as a stimulus, ordinary photoconductivity is observed at wavelengths in the visible region of the spectrum. However, as the wavelength is made shorter (in the near ultra-violet) it is found that an excess conductivity is produced which lasts for days after the light is shut off. Typical build-up and decay curves do not follow an exponential behavior, and at a single wavelength may take days to reach a steady value. Using an external electric field as a probe, it has been found that there is a strongly p-type layer on the surface. Magneto-conductance measurements indicate the mobility is reduced and external electric field measurements indicate the layer becomes more p-type as the surface becomes more highly conducting. These observations are explained in the following way: the light shining on the surface creates electron-hole pairs near the surface; electrons have sufficient energy to jump over the oxide barrier and become trapped in so-called "slow" surface states. This leaves free holes beneath the surface creating a p-type accumulation layer. In order for the conductance to decay back to its initial value the trapped electrons must return to the interior and then recombine with the holes in the accumulation layer.

Physics Research in a Small Institution

Chas. S. Morris, Manchester College

Research in physics has long been regarded as belonging primarily to universities and larger institutions. Because of the greater concentration in these centers of conditions favorable for research, it is to be expected that they will continue to lead the way in this field. However, we have come into a day in which there is a growing feeling that a modest research program is not inconsistent with the teaching function of a liberal arts college and that it may well serve to round out the contribution a small institution is able to make.

Since a small institution must usually operate on a very limited budget and is probably more often than not understaffed, any proposal that a research program either large or small be added is not usually received enthusiastically. With the press of departmental duties and the added responsibilities imposed by the administration to keep the institution running, it seems to the harassed faculty member there can be no time left for anything as elusive as research. Also, however enthusiastic the college teacher may have been about the research problem he undertook in his graduate program the problem may now have become obsolete or else the project was too unwieldy to lend itself to any facilities he may now have available. Other than that no worthwhile project seems to present itself, and without a research project he correctly reasons no research will be possible. Furthermore, the department is rigidly budgeted and to ask for any major increase in his budget would be unfair to other departments, and probably institutional funds would not be adequate to cover his request in any case. These three obstacles of no time, no project, and no money cannot be taken lightly, for it may well be they can be overcome only with difficulty. But if our experience in the physics department at Manchester College is any criterion these obstacles are not insurmountable. Our experience is outlined with the thought that it might be of some value to others who may be interested in developing a research project.

We have found at Manchester that no activity of the department makes more of an appeal to our best students than does our research project. It has therefore been comparatively simple to form a small research group of good students who are eager to help to the limit of their ability. In addition to the benefits accruing to the students involved, their help with details has served to greatly extend the time the research director has had available.

The selection of a suitable project was made possible by the advice and help of those in research in larger centers. Many of you remember the Nuclear Emulsion Conference held at DePauw in April, 1955. This conference sponsored by the DePauw department of physics and the National Science Foundation was a frank attempt to bring together those who were experts in nuclear emulsion research and those who were interested but who only vaguely sensed the possibility of research in this field. For some of us in attendance a chief value of the Conference was the revelation that those in larger institutions were deeply interested in sharing their experiences and know-how with those of us in small centers and in helping us initiate research programs suitable to our limited facilities. As a direct result of this inspiration, visits were made from Manchester to several institutions for consultation on the best research project suitable to our situation. Excellent help was gotten from various members of the Purdue staff and from Dr. M. L. Pool of Ohio State. Later conferences with Dr. S. B. Burson of Argonne and Dr. P. R. Bell of Oak Ridge provided extremely valuable help. In all of these contacts a genuine interest which extended beyond the call of duty for the men involved was shown in helping to initiate a research program at Manchester on an elementary level. As a result of these contacts it was decided to attempt work in gamma ray spectroscopy.

Since this would require funds beyond our budget, a number of possible sources for financial help were considered, with the final decision to apply for a grant from the Research Corporation through their midwest representative, Mr. Walter E. Thwaite. The problem in which we wished to work was definitely phrased and our application submitted. Before presenting our application to their Board, Mr. Thwaite made a personal visit to acquaint himself with our situation, and in due course we were notified of the consideration of our application and of favorable action on it.

After securing advice from those who were working in gamma ray spectroscopy, equipment for constructing a single channel gamma ray spectrometer was secured and assembly begun. The apparatus includes a scintillation probe followed by a linear amplifier and pulse height analyzer with power supply, scaler and register. The probe consists of a thallium activated NaI crystal, 1¾″ in diameter by 1″ thick, optically sealed to the face of a photomultiplier tube. A gamma ray entering the crystal produces a scintillation which is translated by the photomultiplier into an electrical pulse whose energy is proportional to the energy of the gamma ray. The linear amplifier serves to amplify these pulses still maintaining the proportionality of their energy to the energy of the gamma ray which gave rise to them. The pulse height analyzer permits only those pulses to pass whose energies lie within a range determined by the setting of a pulse height or energy range window. The pulses which are allowed to pass are recorded by the scaler and register for a predetermined length of time or the time of a predetermined number is taken. The pulse height analyzer may be adjusted to respond to pulses through a wide range of energies. It is thus possible to record and plot the number of gamma rays per minute of specific energies entering the probe over a wide range of energies. This constitutes a gamma ray spectrum characteristic of the source in which the gamma rays originate.

Since this is not an absolute method for determining gamma ray energies, comparison must be made with the known gamma ray spectra of various radioactive standards. This is in effect a calibration of the instrument and for accurate work this calibration must be rechecked each time an unknown spectrum is run. We have had this apparatus in use for somewhat more than one year. This has been long enough to learn something of its possibilities and its limitations.

One limitation is the inability with a single channel instrument to distinguish between gamma rays resulting from successive energy changes in a given nucleus from those which result from single energy changes in different nuclei. In the search for nuclear energy states this may give a false picture of energy transitions. This difficulty can be relieved by developing a coincidence circuit and the possibilities of the spectrometer thereby greatly extended.

To achieve this end in our project at Manchester application was made to the Research Corporation for a renewal of their grant. This request was considered favorably, and we are now in the process of adding equipment and building a coincidence circuit. To detect gamma rays which result from successive nuclear energy changes and are practically coincident we are using a second probe. This necessitates a second amplifier and pulse height analyzer. We will also add two scalers and registers. One high voltage supply will serve both photomultiplier tubes. The block diagram, Fig. 1, indicates the relation of the component parts, ignoring the high voltage supply. The coincidence circuit is a set of trigger circuits so designed that it will register counts only when pulses are fed into it simultaneously or nearly so from both probes 1 & 2.

In use, analyzer 1 may be set on a chosen gamma ray of any energy and analyzer 2 moved through the spectral range. Scaler 3 will then record counts on those gammas from circuit 2 which are in coincidence with the gamma ray setting of circuit 1. What seemed before to be unrelated gamma rays from energy changes of different nuclei of the isotope under investigation are now seen to be successive energy changes of the same nucleus. This makes possible a more certain identification of energy level transitions in whatever radioactive nucleus is under investigation.

For those who are already expert in the theory and operation of this type of scintillation spectrometer this account will seem completely elementary. For the rest of us, at least for those of us both students and faculty who are developing this equipment at Manchester, it is an exciting and rewarding adventure. We will, of course, be constantly endeavoring to secure data that will make a valuable contribution to this field of physics. It seems worthwhile to point out, however, that whether or not there are significant findings in the special problem under investigation some extremely valuable by-products are accruing. Among these it may be noted there is a general increased interest in physics in the institution, intellectual horizons in the department have been widened, and a definite stimulus toward graduate study and advanced research on the part of the better physics students has been aroused. Perhaps the by-products may in the long run prove to be the most important.

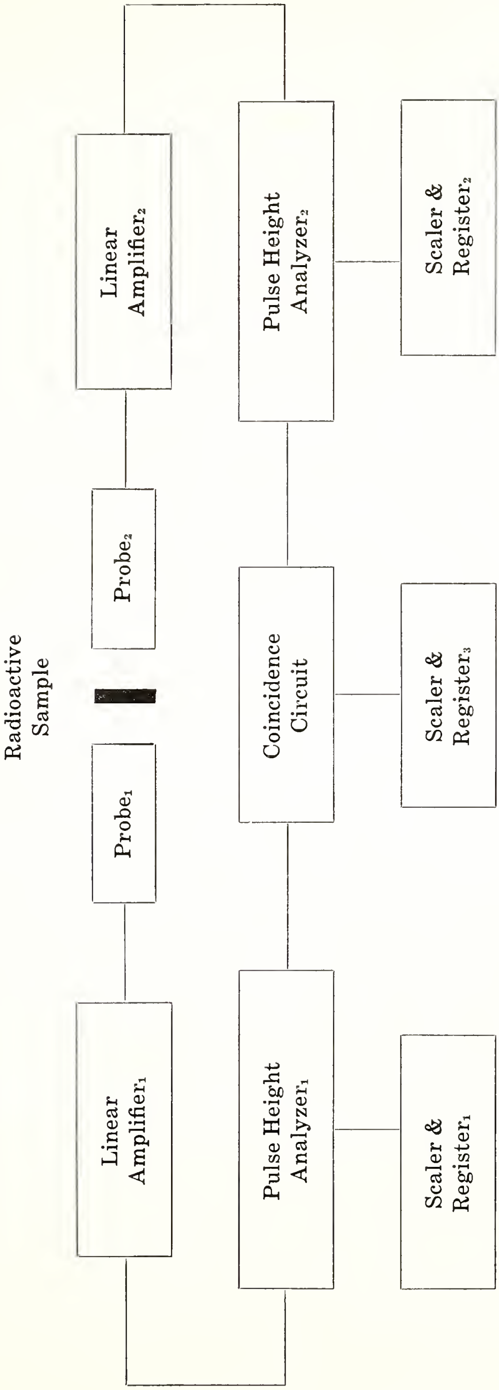
Radioactive Sample
Probe$_1$
Probe$_2$
Linear Amplifier$_1$
Linear Amplifier$_2$
Pulse Height Analyzer$_1$
Coincidence Circuit
Pulse Height Analyzer$_2$
Scaler & Register$_1$
Scaler & Register$_3$
Scaler & Register$_2$

FIGURE 1

Plant Taxonomy

Chairman: JOHN E. PELTON, Butler University

MARION HALL, Butler University, was elected chairman for 1958

ABSTRACTS

Study of a Natural Hybrid Population Among Three Species of *Tragopogon*. A. T. GUARD, Purdue University.—In the spring of 1952 a population of *Tragopogon porrifolius* L., *T. pratensis* L., and *T. dubius* Scop. were found growing on a recent road fill near Lafayette, Indiana. At that time putative hybrids between the various species were observed. These hybrids show much evidence of being F_1 hybrids in that they were intermediate between the parents and highly sterile. Although this was predominantly the case each of the succeeding years, in 1957 there was limited evidence that segregation or back crossing to one of the parent species was evident.

Natural Hybridization of Helianthus Longifolius with H. Atrorubens and H. Occidentalis. DALE M. SMITH, Univ. of Kentucky and WILLIAM C. MARTIN, Indiana University.—A mixed population of diploid perennial sunflowers composed of *Helianthus atrorubens* L., *H. longifolius* Pursh, *H. microcephalus* T.&G., and *H. occidentalis* Riddell was encountered in September, 1957, near Albertville, Alabama. The plants were scattered along a rather steep road embankment composed of sandy clay loam into which a number of large quartzite boulders were mixed. *Helianthus longifolius* was found along the entire extent of the embankment, while *H. occidentalis* and *H. atrorubens* were localized at opposite ends, and *H. microcephalus* grew along the edge of an adjacent woodlot.

One putative hybrid between *H. occidentalis* and *H. longifolius* was found, and no hybrids involving *H. microcephalus* were evident, but a large putative swarm of *H. atrorubens* x *H. longifolius* was present. The putative hybrids showed considerable variation in leaf and phyllary characters, while yellow disc corollas were apparently dominant over the purple-tipped corollas of *H. atrorubens*.

These examples are the first records of hybridization between these species and bring to twenty-four the total number of natural hybrids encountered between diploid species of sunflowers.

On the Origin of the Term 'Weed'

LAWRENCE J. KING, Boyce Thompson Institute for Plant Research, Inc.

It is of interest to examine the history of a word that is so commonly used yet so difficult to precisely define. The Oxford English Dictionary (1933) traces the earliest usage in the English language back to the Anglo-Saxon "weod" as used by Aelfred (c. 888), and indicates it is of unknown origin. However, further search has revealed that "weed" might be derived from earlier forms of the German *weyt* (c. 1150), the Dutch *weet* (c. 1597) and *weeda*, the Belgian *weedt* (c. 1576) etc. for woad or dyeweed, (*Isatis tinctoria* L.).

A comparative study of the equivalents used for "weed" in several of the Germanic and Romance languages has shown how descriptive many of these terms are (4). Some examples here would be the French, *mauvaise herbe*, the Italian *malerba*, and the German, *Unkraut.* Attempts to trace our modern term back to any recognizable equivalents in the Latin language have been unsuccessful. Rather, since a goddess of weeding, *Runcina*, was worshipped during the Augustinian period variations such as *runco*, *erunco*, and *runciatio* acquired the meaning of "weeding." The descriptive term for the leaf margin, runcinate—as applied to the dandelion leaf, for example—appears to be our only current derivative (4, 9).

The cruciferous genus, *Isatis*, consists of some 30 species. *Isatis tinctoria* is apparently a native in south-eastern Russia where it is recorded as growing on exposed hillsides and in brushy places. It is one of the most widely distributed species of the genus, and occurs throughout Europe, North Africa, and Asia as far as China and Japan. Woad, or "Devil's Weed" is also common in western Tibet, Afghanistan, etc. occurring both wild and cultivated. It is also grown in certain regions of China and yields the indigo of that country. The seeds were also used as a source of oil (2, 5, 7).

It is a biennial or perennial herb with characteristics of a plant belonging to the temperate zone. The active period in England extends from about February to November, the resting period from December to January. The rosette is formed the first season, with flowers and fruit forming the second season. The foliage leaves live throughout the winter. It flowers in July and sets seed in September. Its cultivation from the earliest times has led to its occasional appearance in an apparently spontaneous state in other parts of Europe, including England. It is one of those species which occasionally appears in plenty when ground is newly turned, doubtless on the site of former woad-crops, from which stragglers have persisted and seeded from time to time. Perhaps here its weedy aspect becomes obvious. In England it is often found in old lime pits and chalk quarries—thus indicating an alkaline soil requirement. It thrives in rich soil and soon exhausts it to such an extent that in former times the woad crop had to be frequently shifted to new land (1, 6).

Knowledge of this plant extends far back into antiquity. It is briefly described by Dioscorides and illustrated under the Greek name "Isatis" (8). In the ancient Latin language it was referred to as *vitrum*, and a reference occurs in Caesar's *De bello gallico* (V, cap. xiii) : "*omnes vero se britanni vitro inficiunt, quod coeruleum efficit colorem atque hoc horridiores sunt in pugna aspectu.*" In later Latin *vitrum* became *glastum.*

Dr. J. B. Hurry in 1930 published an extensive study of the woad plant and its culture (3). This plant had been cultivated since ancient times for its blue pigment with the name *wăd* applied in England to this plant as far back as the 13th Century, although nearly extinct as a crop since 1900. Hurry in examining the comparative philology of "woad" refers to the study of M. Heyne who suggested that this problem involves a root which takes two forms. The first is *wis-*, as met with in the Greek *isatis* (or variations in spelling thereof) and in the Gothic *wiz-dila.* The second form is *wi* passing into the Latin *vi-trum*, the old German *wai-d*, Middle German *waidso*, Old German *wăd*, and finally into the English *woad.*

It is interesting that the two most ancient forms appearing in print, *wăd* for woad, and *weod* for weed maintained separate and distinct meanings although they sounded much alike and following our present analysis they were derived from some common root. Just how "weod" or "weed" arose from the early Germanic forms listed earlier is not clear. However, some speculation may be in order. Since the proto-Germanic forms given in the early part of this paper were used as common names for the woad plant, they, or their modern counterparts, never acquired the current meaning of our term "weed". In the German language, for example, *weyt* or *waidt* being pre-empted for the crop plant *Isatis*, another word, *Unkraut* came to mean quite well the modern equivalent of "weed." In this connection it is interesting to observe that the verb *wieden*, "to weed" is retained in the Dutch language although the noun here is *Onkruid*—a variant of "*Unkraut*".

Perhaps "weed" is another example of language as an accident of usage. It alone of all the equivalents for "weed" in both the Germanic and Romance languages has no intrinsic meaning or self-description that would appear appropriate. The suggestions for origin proposed are certainly only tentative—i.e., until further proof can be martialed, or the entire argument invalidated by new information. One last question arises, has *Isatis tinctoria* ever been classed as a weed? The answer is "no" for the majority of the countries examined—the two exceptions being Chile and a localized area in western Virginia. Why should this be so? It probably resides in two aspects of the life of the plant—the fact that it is dicyclic, requiring two seasons for maturity which would largely rule it out as a weed of annually cultivated ground; and secondly its great dependence upon seeding and proper care for its survival since a successive series of cultigens were selected, developed and carried throughout several millenia.

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Contributions to the Flora of Wayne County, III

CARROLLE A. MARKLE,[1] Earlham College

A study of the pteridophyte flora and monocotyledonous plants of Wayne County, Indiana, was made during the academic year 1956-1957. This was a continuation of work reported in the 1955 and the 1956 Proceedings of the Indiana Academy of Science, and, with the exception of the genera *Crataegus*, *Rosa*, *Rubus* and *Salix* among the woody dicotyledons, and the families *Compositae*, *Cyperaceae* and *Gramineae*, completes the report, to date, of the flora of this county. As before, no species are included in the following list unless previously reported by Deam or now present in the Earlham College Herbarium; hence the list is not to be considered complete for the County.

The following list includes 81 species in 44 genera and 17 families. There are 35 species recorded here which were not included in Deam's Flora of Indiana, for Wayne County. The sequence of genera is that used in Deam's Flora and the nomenclature is in accord with that used in Gray's Manual of Botany, 8th Edition, but the species are given alphabetically within the genera.

A list of the Pteridophyte and Monocotyledonous Species of Wayne County, Indiana

(Exclusive of Species of the Families *Cyperaceae* and *Gramineae*)

Ophioglossaceae: *Ophioglossum vulgatum* L. var. *pycnostichum* Fern.[2], *Botrychium dissectum* Spreng., *Botrychium dissectum* Spreng. var. *obliquum* (Muhl.) Fern., *Botrychium virginianum* (L.) Sw. Osmundaceae: *Osmunda regalis* L. var. *spectabilis* (Willd.) Gray[2]. Polypodiaceae: *Cystopteris bulbifera* (L.) Bernh., *Cystopteris fragilis* (L.) Bernh., *Cystopteris fragilis* (L.) Bernh. var. *protrusa* Weatherby, *Onoclea sensibilis* L., *Dryopteris hexagonoptera* (Michx.) Christens., *Dryopteris spinulosa* (O. F. Muell) Watt.[3] *Dryopteris Thelypteris* (L.) Gray var. *pubescens* (Lawson) Nakai, *Polystichum acrostichoides* (Michx.) Schott., *Athyrium Filix-femina* (L.) Roth var. *asplenioides* (Michx.) Farw.[3], *Athyrium Filix-femina* (L.) Roth var. *Michauxii* (Spreng.) Farw. forma *rubellum* (Gilbert) Farw.[3], *Athyrium pycnocarpon* (Spreng.) Tidestr., *Athyrium thelypterioides* (Michx.) Desv.[3], *Camptosorus rhizophyllus* (L.) Link, *Asplenium platyneuron* (L.) Oakes, *Adiantum pedatum* L.

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[1] The author wishes to acknowledge the financial assistance afforded by a grant received from the Research Grant Committee of the Indiana Academy of Science. She also wishes to express her appreciation for the work done by Mrs. Lois Joyner, Earlham '55. The organizational work done with the herbarium material, and the preparation of this list was almost entirely her work.

[2] Reported previously from Wayne County but not known to occur now.

[3] Species considered relatively rare, with only one or two stations, at this time.

Equisetaceae: *Equisetum arvense* L., *Equisetum fluviatile* L., *Equisetum hyemale* L. var. *affine* (Engelm.) A. A. Eaton. Selaginellaceae: *Selaginella apoda* (L.) Fern. Pinaceae: *Juniperus communis* L. var. *depressa* Pursh,[2] *Juniperus virginiana* L. var. *crebra* Fern & Grisc.

Typhaceae: *Typha angustifolia* L.[2] Alismataceae: *Alisma subcordatum* Raf., *Sagittaria latifolia* Willd. Araceae: *Acorus Calamus* L., *Symplocarpus foetidus* (L.) Nutt., *Arisaema atrorubens* (Ait.) Blume, and forma *zebrinum* (Sims) Fern., and forma *viride* (Engler) Fern., *Arisaema Dracontium* (L.) Schott.[3] Lemnaceae: *Spirodela polyrhiza* (L.) Schleid., *Lemna minor* L. Commelinaceae: *Commelina communis* L., *Tradescantia subaspera* Ker., *Tradescantia virginiana* L. Juncaceae: *Juncus bufonius* L., *Juncus diffusissimus* Buckl., *Juncus Dudleyi* Wieg., *Juncus effusus* L. var. *solutus* Fern. and Wieg., *Juncus nodosus* L., *Juncus tenuis* Willd., *Juncus Torreyi* Coville, *Luzula multiflora* (Retz.) Lejeune.

Liliaceae: *Uvularia grandiflora* Sm., *Hemerocallis fulva* L., *Allium canadense* L., *Allium cernuum* Roth, *Allium tricoccum* Ait., *Lilium michiganense* Farw.[3], *Erythronium albidum* Nutt.[3], *Erythronium americanum* Ker, *Camassia scilloides* (Raf.) Cory, *Ornithogalum umbellatum* L., *Asparagus officinalis* L., *Smilacina racemosa* (L.) Desf., *Smilacina racemosa* (L.) Desf. var. *cylindrata* Fern., *Smilacina stellata* (L.) Desf.[3], *Polygonatum biflorum* (Walt.) Ell., *Polygonatum pubescens* (Willd.) Pursh, *Trillium flexipes* Raf., *Trillium flexipes* Raf. forma *Walpolei* (Farw.) Fern., *Trillium grandiflorum* (Michx.) Salisb., *Trillium nivale* Riddell, *Trillium recurvatum* Beck, *Trillium sessile* L., *Trillium sessile* L. forma *viridiflorum* Beyer, *Smilax herbacea* L., *Smilax laisoneura* Hook., *Smilax rotundifolia* L., *Smilax tamnoides* L. var. *hispida* (Muhl.) Fern. Amaryllidaceae: *Hypoxis hirsuta* (L.) Coville[2]. Dioscoreaceae: *Dioscorea villosa* L. Iridaceae: *Iris virginica* L. var. *Shrevei* (Small) Anderson, *Belamcanda chinensis* (L.) DC.[3], *Sisyrinchium albidum* Raf., *Sisyrinchium angustifolium* Mill. Orchidaceae: *Orchis spectabilis* L.[3]

Evidence of Introgressive Hybridization and Mutation in Certain Colorado Populations of *Aquilegia*

JEANETTE S. PELTON, Butler University[1]

Hybridization has often been reported for the genus *Aquilegia* (Anderson and Schafer 1931, Cockerell 1916, Grant 1952, Skalinska 1928a, 1928b, 1929, 1931). When individuals of two species of *Aquilegia* occur sympatrically isolating mechanisms between them are often weak or absent permitting crossing, the resulting hybrids frequently being fertile. Such a sympatric occurrence of individuals of *Aquilegia caerulea* James and *A. elegantula* Greene in Gunnison County, Colorado was the basis for the present study, in which the possibility of introgressive hybridization was investigated. In addition, the discovery of possible mutations in the putative hybrid swarm will be discussed.

Methods

The plants included in the present study grew near the Rocky Mountain Biological Laboratory, which occupies the ghost town of Gothic at 9,500 feet nine miles north of Crested Butte in Gunnison County, Colorado. In the study area plants of *caerulea*, characterized by large blue and white erect flowers, grew either in the full sun of *Festuca* dominated meadows or in the semi-shade of Aspen groves where soil conditions were fairly moist. By contrast, the *elegantula* members have smaller red and yellow nodding flowers and are restricted locally to rocky, very moist hillsides in the shade of Spruce-Fir forests. An area transitional between these two distinct habitats included an intermixture of Spruce, Fir, Aspen, open meadow, and a streambank site. A moister soil prevailed in this area. Here, the putative hybrid swarm was growing. In the summer of 1957 collections of both species and their apparent hybrids were made from the extreme and transitional habitats described above.

Anderson's hybrid index (Anderson 1949) was computed on 44 living flowers from the collection. These flowers are retained as voucher specimens (Nos. 601-645) in the personal herbarium of the author. The eight characteristics used in the index, based on those used by Harrington (1954), are as follows: (1) length of spur, (2) color of spur, (3) length of sepal, (4) color of sepal, (5) length of petal, (6) color of petal, (7) stamens exserted or not, and (8) flowers nodding or erect. Two points were scored for characteristics that resembled *caerulea*, zero points for those like *elegantula*, and one point for intermediate characteristics. Thus, a plant of pure *caerulea* would score sixteen points, one of *elegantula* zero points, and putative hybrids an intermediate score.

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[1] The author is grateful for use of facilities of the Rocky Mountain Biological Laboratory, and to Dr. John F. Pelton for field assistance and criticism of the manuscript.

Results

Results of the hybrid index described above vary from zero to sixteen points with most of the individuals scoring near the *caerulea* parent.

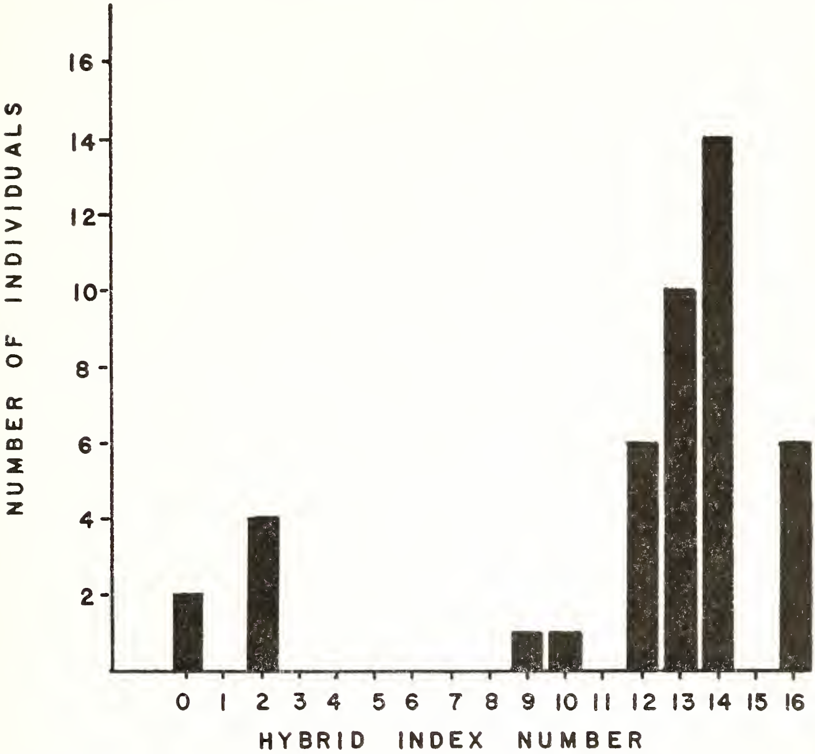

Figure I. Results of the hybrid index for 44 flowers rated for 8 characteristics. 2 points were scored for *caerulea* characteristics, 0 points for those of *elegantula*, and 1 point for intermediate conditions.

These results are summarized in Figure I. The distribution of the scoring of the eight characteristics used in the index is shown in Table I, together with the range of variation given for each species by Harrington (1954).

In addition to the above results several different appearing flowers were noticed in the study area. These were collected and are included in the voucher collection (Nos. 646-651) for this study. Among the variations were flowers that were entirely spurless, some with greatly reduced spur length, and some with variegated blue and white petals. One spurless flower also had blue petals as well as sepals and was on the same plant with normal appearing *caerulea* flowers. The two other spurless flowers, representing different plants, had whitish sepals and petals tinged with green and light blue.

Discussion

On the basis of the results of the hybrid index introgressive hybridization, as defined by Anderson and Hulbricht (1938), may have occurred

TABLE I. Distribution of characteristics used in the hybrid index. The characteristics are those used by Harrington (1954)

Characteristics	Number of Flowers		
	caerulea	intermediate	elegantula
(1) Length of spur caerulea: 30-77 mm long elegantula: 15-22 mm long	37	3	4
(2) Color of spur caerulea: blue elegantula: red	8	30	6
(3) Length of sepal caerulea: 20-40 mm long elegantula: 7-11 mm long	38	3	3
(4) Color of sepal caerulea: blue elegantula: green & red	6	32	6
(5) Length of petal caerulea: 15-25 mm long elegantula: 7-11 mm long	35	4	5
(6) Color of petal caerulea: white elegantula: yellow	36	2	6
(7) Stamens exserted or not caerulea: stamens little if any longer than petals elegantula: stamens 4-6 mm longer than petals	32	4	8
(8) Nodding or erect flowers caerulea: flowers erect elegantula: flowers nodding	24	11	9

between *Aquilegia caerulea* and *A. elegantula* in the area studied. While both of these species are regarded by Munz (1946) as valid species, it is well known that hybridization between distinct species of *Aquilegia* will occur either in nature or artificially. Evidence that hybridization was followed by backcrossing to the parental types, especially to the *caerulea* parent, can be inferred from the index numbers (Fig. I). For example, thirty-one of the forty-four flowers scored 10 to 14 points, which is close to the 16 points allotted to *caerulea.* Analysis of the habitat of the putative hybrid swarm might also support this hypothesis. While the habitat contained some of the requirements of *elegantula* the open meadows, Aspen association, soil condition, and sun-shade balance would be more favorable to *caerulea* backcrosses. Thus, if Anderson's hypothesis that habitats more similar to those of one parental species of a hybridizing pair of species would favor survival of the backcross to that parental type is accepted (Anderson 1948) the above conclusion would be possible. Further study of the ecology of the area over a period of years, however, is necessary to determine whether these backcrossed plants will continue to survive and maintain their separate identity. The above conclusions can be considered tentative, further study being needed such as artificial crosses between the two species and pollination studies such as that by Grant (1952).

Evidence of introgressive hybridization is not the only noticeable change taking place in these populations of *Aquilegia.* In addition, radical differences in flower configuration in some of the individuals were observed. These variations in phenotype could be the result of mutations. The possibility of increased mutation in an area of putative hybridization is intriguing in light of the suggestion by Stebbins that hybridization may increase the mutation rate (Stebbins 1950). The evolutional significance of such an hypothesis, however, must wait further understanding of the genetics of *Aquilegia,* which is dependent upon breeding studies and careful examination of samples of allopatric species populations as well as the sympatric ones.

Summary

Evidence of possible introgressive hybridization between *Aquilegia caerulea* James and *A. elegantula* Greene was obtained in a location where the two species meet in Gunnison County, Colorado. A hybrid index based on eight characteristics for 44 individuals is presented. In addition, several possible mutations were found in the putative hybrid population, giving support to the hypothesis that hybridization may increase the mutation rate.

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PSYCHOLOGY

Chairman: Kenneth M. Michels, Purdue University

George Lovell, Wabash College, was elected chairman for 1958

ABSTRACTS

Strength of Secondary Reinforcement as a Function of the Quality of Food Reward. K. M. Michels and G. W. Lewis, Purdue University.—Three groups of hooded rats were given eight days of training under each of two different reward conditions. One group received a highly preferred food in a black feeding box and a less highly preferred food in a white box. A second group received the highly preferred food in a white box and the less highly preferred food in a black box. The third group received both foods in a black and white striped box.

Following the training period the animals were run on a black-white discrimination problem using a Y-maze with a water incentive. Half the members of each group were run with the white alley correct and half with the black alley correct.

Significant differences were obtained between the subgroups run to the color previously associated with the preferred food and the subgroups run to the color previously associated with the nonpreferred food.

The results appear to support the hypothesis that the strength of secondary reinforcement varies as a function of the quality of food reward.

The Effect of Hue, Brightness and Saturation on Color Preference Considering Various Contexts. E. J. McCormick, R. E. Blanchard and G. G. Karas, Purdue University.—Twenty-four white male subjects were asked to express their preferences for 73 colors for each of four "contexts", namely for a sport shirt, den wall paint, an automobile, and in the "abstract." The judgments were obtained by having the subjects sort the 73 colors into a seven-interval Thurstone-type scale. An analysis of variance design was employed to test the effects of hue, saturation, and brightness as characteristics affecting color preference for the four contexts.

It was found that hue, brightness, and saturation had a significant effect upon color preferences. Agreement indices were computed on the subjects' color preferences which revealed a certain amount of consistency between the preferences of the subjects.

The Effect of Decrease in Size of Reward on Runway Latency Scores in the Hooded Rat. Robert H. Wright, Purdue University.—The effect on runway latency scores of a decrease in size of reward was studied under two periods of deprivation. It was found that decrease in size of reward resulted in an increase in the time hooded rats spent in crossing a runway. This increase was found to be transitory, however, and after ten trials the period of deprivation appeared to be the main factor influencing runway crossing time. The results are discussed with respect to the results of previous investigators and theoretical implications.

Visual Discrimination of Small Objects by Raccoons. JOHN I. JOHNSON, JR., Marquette University.—As a further investigation of the visual acuity of raccoons *(Procyon lotor)* in laboratory testing situations, this study is concerned with their ability to distinguish very small three-dimensional objects. After learning to discriminate between two objects of 1 inch in all three dimensions, nine animals were required to discriminate between smaller and smaller replications of these objects in order to secure a food reward. All nine raccoons discriminated objects of ½ inch, ¼ inch, and ⅛ inch in all three dimensions (i.e., 1/4, 1/16, and 1/64 cubic inches, respectively), with equal facility. It can be concluded that raccoons can discriminate objects of the smallest sizes practicable for testing purposes. In addition, discrimination of the small sized objects improved from one set of replicated objects to another, regardless of the particular set of objects involved, indicating that such discrimination, or acuity, improves with practice.

Gastrointestinal Activity in Hunger and After Food: the Question of Hunger Pangs. LORAZE GARAFOLO and R. C. DAVIS, Indiana University.—By a new method the activity of the stomach and intestinal tract was recorded without the insertion of any foreign object into the stomach or other parts. Records were made on 8 *S*s after at least eight hours without food and after their consumption of a light breakfast. Records were measured so that amplitude and frequency of waves may be compared.

Characteristic rhythms of stomach and intestinal tract are observed. These are generally quite small or absent before the food and increase significantly in all four quadrants of the abdomen after eating. There is a significant intercorrelation in the increase in the several locations.

The results cast doubt on the common belief that during hunger there are pangs associated with large slow contractions of the stomach. These may be induced by the balloon introduced into the stomach as a recording device.

Aggression and Avoidance in the C57BL Mouse. VICTOR H. DENENBERG and ROBERT W. BELL, Purdue University.—Investigations of aggression in the C57BL mouse have been previously concerned mainly with the elicitation of competitive and fighting behavior, inter-strain differences in aggression, and individual differences. Some social correlates of aggression have been isolated, notably early competitive experience, maternal influences, amount of sexual activity, and formation of dominance-submission hierarchies.

The present study was an attempt to relate aggression and avoidance learning. The experimenters hypothesized that both aggressive behavior and learning are adaptive functions, aiding the organism in survival.

Four indices of aggression were compared with two measures of learning to avoid shock. A positive relationship was found to exist between some of the measures of aggression and learning as measured in this experiment.

Differences Between Normals and Psychotics in the Perception of Serially Diffused Visual Stimuli. LIONEL W. MOSING, Purdue University.—To objectively determine whether individuals from behaviorally deviant groups, i.e., psychotics and normals, differ in the perception of visual stimuli of varying degrees of ambiguity, a perceptual recognition test, Form Emergence Series (FES), was developed. FES consists of twenty sequences of optically blurred photographs of common animals and objects presented seriatim to the subject at five levels of diffusion, from a very blurred to a clear representation of the object. The subject's task was to attempt identification of the object at each level of ambiguity. Response time and the verbatim responses of each subject were recorded for every item.

The FES was administered to 100 college students and 50 institutionalized psychotics of comparable age, sex, and intelligence. As hypothesized, analyses of variance indicated that the psychotics required significantly greater stimulus clarity for recognition, significantly more time to respond, and produced fewer prerecognition responses than did the normal group.

Adequate concurrent validity was indicated by a significant point biserial correlation of .83 between FES total score and the normal-psychotic dichotomy. Total score internal consistency was .98. For the psychotic group a significant quadraserial correlation of .73 was found between total score and prognosis rating by the clinical staff.

ZOOLOGY

Chairman: Eliot Williams, Wabash College

William Hopp, Indiana State College, was elected chairman for 1958

ABSTRACTS

Preliminary Studies on Pigmentation in Cave Planarians.[1] Eliot C. Williams, Jr., Wabash College.—During the course of field studies on the fauna of Donaldson's Cave, Spring Mill State Park, Mitchell, Indiana, an interesting situation was observed in the planarian population. Within the cave the planaria lack pigment except for the eye spots and even these were lacking in some forms. In the stream issuing from the cave, planaria of varying degrees of pigmentation are present. Field observations revealed a relationship between the distance from the cave mouth and the degree of pigmentation. There are more light-colored forms in the stream near the cave mouth than there are downstream. Dr. Libbie Hyman, who described the white planarian from this cave as *Phagocota subterranea* in 1937, examined a series of these worms ranging from white to darkly pigmented and she reported that the only apparent difference between the white form and *Phagocota gracilis*, the common epigean species of the region, is that *P. subterranea* is somewhat smaller in size and lacks pigment.

Laboratory experiments are in progress using two constant temperature cabinets at 11° C, one of which is provided with constant light and the other is completely dark. Observations after three months give some indications of a difference in pigmentation between worms which have been in constant light and those which have been in constant dark. Worms were cut in half and the two halves allowed to regenerate—one in the light cabinet and the other in the dark. Those which have regenerated in the dark show less pigmentation in the regenerated portions than corresponding halves which have been in constant light. Even the original portions of the worms are slightly lighter in many cases. All worms have been fed twice weekly on beef liver and are transferred to clean dishes of dechlorinated tap water following each feeding. All transfers of those worms in the dark cabinet are made in a dark-room with illumination provided by a red photographic dark-room light. They are exposed to this illumination for a very brief time. Comparisons of the worms for degree of pigmentation were also made with this illumination.

Measurements made each week on a series of worms of varying pigmentation, some in constant light and some in constant dark, show no significant difference in rate of growth between those in the dark or light or between those of varying shades of pigmentation.

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[1] Supported by grants from the Adventurers Club Foundation and the National Science Foundation.

Attempts to graft halves of white and dark worms together have thus far been unsuccessful, but this work is being continued.

Neither asexual or sexual reproduction have occurred as yet in laboratory cultures. Pairs of white and dark worms are isolated so that any genetic control over degree of pigmentation may show up if sexual reproduction does occur.

Further Studies on the Axenic Cultivation of Planarians. C. A. MILLER, J. H. BRUMBAUGH and W. H. JOHNSON, Wabash College.—The planarians used in these experiments were obtained from Turtox Biological Supply House and are tentatively identified as *Dugesia dorotocephala.* Stock cultures of the worms have been in an active stage of asexual reproduction (fission) for the past four months, following a period of sexual reproduction in our laboratory.

Adult individuals of 2.5 cm. in length were freed of all associated forms of life by treating them with a mixture of 12 antibiotics proceeded by sterile water washes through a series of depression slides. The antibiotics used in μg per ml of de-chlorinated tap water were as follows: aureomycin•HCl, 100; chloromycetin 100; tetracycline•HCl, 100; streptomycin sulfate, 50; neomycin sulfate, 50; erythromycin, 50; albamycin, 50; vancomycin, 5; M-16655 (Eli Lilly), 5; trypaflavin, 5; filipin, 5; and penicillin, 100 units. Single washed planarians were kept in the antibiotic solution for at least 72 hours to produce the maximum percentage of axenic worms. Of 40 planarians so treated only 5 were found to be contaminated with bacteria or fungi, and these were confined to a single experiment of six treated worms. Extensive test for detection of contamination of the treated worms have been made, including tests on macerated tissues of the worms.

A few worms have now survived three months, without feeding for the first month of that period. Several fissions as well as complete regeneration of cut portions of axenic planarians have occurred. All axenic worms have fed extensively on sterile egg yolk. However, the egg yolk appears to be deficient in some growth requirement(s) for the worms. Extracts from liver, milk, cereal grasses and yeast are being used to supplement the egg yolk.

Nuclear Proteins and Genetic Information. JAY BARTON II, Saint Joseph's College.—The properties of a firmly bound complex of DNA and insoluble protein isolated from a variety of cell nuclei have been further investigated. Approximately one-fourth of the total DNA of the nucleus is involved in this complex. The purine pyrimidine base composition of the DNA is identical to that of the total DNA of the nucleus indicating that the DNA in the complex is a representative sample of the many different species of DNA molecules existing in the nucleus. A small amount of RNA is present. The protein component of the complex can be shown to be similar to a protein fraction of the microsomes in solubility, amino acid distribution, end group distribution, etc. The correlation of such analytic data with metabolic studies from other laboratories supports a postulate that the insoluble protein of the complex operates as an information transfer system between the nucleus and the microsomes.

The Development of the Spleen of *Taricha torosa* and its Experimental Modification.[1] LOUIS E. DELANNEY,[2] Wabash College.—The spleen is usually visualized to develop as a mesenchymatous aggregation in the dorsal mesentery in the vicinity of the stomach and duodenum, e.g., in the chick. However, in the West Coast salamander, *Taricha torosa*, initial splenogenesis seems not to be mesenchymatous proliferation but rather a vascularization of the dorsal surface of the gut, seen at least by Twitty Stage 42. During succeeding stages this vascular region becomes delineated from the dorsal surface of the gut and definitively lies in the dorsal mesentery; in this period there is an increase in the sinusoidal appearance of the presumptive spleen and more and more cells of a mesenchymatous or blast nature take residence. By the feeding stage (Stage 46) the small, red spleen is seen through the relatively pigment-free and pellucid body wall. In view of the known simulatory effect on embryonic spleen growth by adult spleen grafts to the chorio-allantoic membrane in the bird and in view of the excellent visibility of the developing spleen in *T. torosa in situ*, adult *T. torosa* spleen was presented to late embryos and early larvae by intracoelomic and dorsal fin grafts. Contrary to the well-established evidence of splenic size increase in birds under comparable conditions, seemingly converse results appeared in *T. torosa:* the spleen sometimes failed to be evident. Preliminary sections of "spleenless" animals shows that the failure is not due to absence of initial splenic elements but to a failure of secondary events of splenogenesis. The possibilities of immunological responses are considered and a tentative postulate reconciling the differences in avian and amphibian results is indicated.

A New Type of Killing Action in a Stock of *Paramecium aurelia* from Panama. MYRTLE V. SCHNELLER,[3] Indiana University.—A paramecin that produces the first signs of its effect in ten minutes at room temperature (22-24° C.) has been discovered in a new stock of *P. aurelia* from Panama. This stock is closely related to Varieties 4 and 8. However, it kills only Varieties 3, 5 and 9, none of which overlaps Variety 8 and only slightly Variety 4 in geographical range. Other killers are known in both Varieties 4 and 8, but no other shows any action in less than 2 hours nor this type of killing. It is characterized by the formation of huge blisters, swimming backwards, loss of shape, settling to the bottom, then death.

The paramecin is released into the medium, where it remains active for some time. Animal-free fluid was centrifuged and the supernatant proved very slightly reactive, but the precipitate very strongly so.

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[1] Supported by a grant from the National Science Foundation.

[2] Carnegie Institution of Washington Fellow in Embryology, Summer, 1957, during which time some of the evidence presented was obtained.

[3] This work was supported by a grant from the American Cancer Society to T. M. Sonneborn, Indiana University.

Under the phase microscope, kappa-like particles can be seen in the animals, but they are of much larger size than any other known kappa.

With the advantage of its speed of action, this culture offers the possibility of solving some of the hitherto baffling problems of paramecin action.

Factors Affecting the Toxicity of Sodium Pentachlorophenate to Fish. CATHERINE A. BERKA, Purdue University.—One of the more important industrial toxicants that is released into streams is sodium pentachlorophenate. Experimental studies have shown that it is extremely toxic to fish. Concentrations as low as 0.04 parts per million are often fatal to minnows. In other investigations it was demonstrated that the relative toxicity of this material was influenced by a number of environmental factors including temperature and pH.

Homologies in the Male Reproductive System of the California Pocket Gopher (*Thomomys bottae navus* Merriam). 1957. W. C. GUNTHER, Valparaiso University.—The secondary reproductive organs of the adult male California pocket gopher consist of a single, median dorsal prostate and two lateral prostate glands; two coagulating glands; and two seminal vesicles. The ducts of these separate glands are traced to their respective positions in a structure not heretofore described, tentatively designed as a common ejaculatory duct. This single, median common duct empties into the urethra. Physiological evidence of the activity of the coagulating gland was not detected. A rather complete series of embryos indicate that the glands may properly be homologized with glands of a similar nature in man, rats, guinea pigs, and moles. The common ejaculatory duct appears to arise from the embryonic urogenital sinus. Its exact counterpart in other mammals has not come to this author's attention. The paired bulbo-urethral glands were found to arise also in embryos from the same primordium as similar glands in other mammals.

A Parallelism of Cheek Skin Color in Plethodontid Salamanders. ALBERT E. REYNOLDS, DePauw University.—Skin color descriptions of *Plethodon jordani jordani* and *Desmognathus ochrophaeus carolinensis* are given and utilized to emphasize a striking parallelism between cheek skin color of the former and the "imitator" variety of the latter. Macroscopic external appearance is correlated with histologic skin studies.

The Records of Freshwater Medusae in Indiana[1]

CHARLES F. LYTLE,[2] Indiana University

Introduction

A considerable number of American records of the freshwater medusa, *Craspedacusta sowerbii* Lankester, have been published in the last several decades. Because of its unusual and puzzling habits, this animal has become a curiosity and has aroused the interest of a great many biologists. Medusae of this species have occurred in a number of interesting habitats. As pointed out by Pennak (8) recently, the majority of records are from small, artificial lakes or ponds which were usually less than 40 years old when medusae were observed. Among the more unusual habitats recorded are backyard fishponds, water lily tanks, flooded quarries in limestone and granite, abandoned gravel pits, and even a municipal water filtration plant. There are also a few records for large natural and artificial lakes, but these appear to be exceptional.

Craspedacusta sowerbii is nearly worldwide in distribution and is thought to have evolved from marine ancestors in the Yangtze River system of China. Records now exist for 30 of the United States including all those states bordering Indiana. These medusae are now found frequently enough that they can no longer be considered a rarity; however, the occurrence of medusae in any new habitat is still noteworthy since all the records for this country total only about a hundred. As a consequence, little is known about the distribution of the species except something of the general range.

In a few states like Ohio, Pennsylvania, New York, and Virginia, there are several records for freshwater medusae, but for most states we find only one or a few scattered reports. The records for Ohio and Pennsylvania were recently summarized by Dexter, Surrarrer and Davis (3); and the distribution of freshwater medusae in Maryland, Virginia, and the District of Columbia is described in my forthcoming paper. In contrast to a relatively large number of records for the state of Ohio, there are few records for the other states bordering Indiana. Illinois has five scattered records in the southeastern part of the state; Michigan has one record near the southeastern corner; and Kentucky has several records, but all except one are for parts of the Kentucky River System.

The purposes of the present report are to summarize the previous records of *Craspedacusta* in Indiana and to present 13 new reports for this state. This information was obtained in the course of our work on the development and physiology of the species and is not the result of an organized ecological investigation; therefore, some of the data are fragmentary.

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[1] Contribution No. 638 from the Zoology Dept., Indiana University.

[2] I would like to thank the many people who have contributed to this study; especially Dr. Sears Crowell, Dr. D. G. Frey, Dr. F. Payne, and Mr. J. B. Stahl of Indiana University; and Mr. W. R. Eberly of Manchester College.

Previous Indiana Records

There are published reports for *Craspedacusta* in only four places in Indiana. Payne (6) (7) reported the species in Boss Lake, a small artificial lake near Elkhart, between 1918 and 1924. This was one of the earliest reports of *Craspedacusta* in the United States, and using specimens from Boss Lake, Dean Payne worked out the complete life history of the species for the first time. Present owners of Boss Lake (now known as Crandall's Pond) recently stated that medusae appeared irregularly for some years after Payne's studies, but none have been noticed in the last eight or ten years.

Several years after Payne's work Allyn and Rettgar (1) reported medusae in a flooded gravel pit in Vigo County near Terre Haute. Medusae were seen here several times from 1932 to 1937. Medusae were observed in an old gravel pit near Franklin in Johnson County during September of 1931, but none were found on several revisits in subsequent years (2). Garner and Markle (5) and Garner (4) have reported the presence of *Craspedacusta* in Crescent Lake, a small artificial lake near Richmond. Medusae were observed during August and September of 1931, and they continued to appear for a few years, but then seemed to disappear until the late summer of 1954, when they were seen again.

New Indiana Records

Medusae have been recorded in 13 new localities in the state. New records continue to be added to this list, and undoubtedly many other observations of medusae remain unknown to the author. Some areas of the state have been extensively covered, others less extensively covered, the number of reports does not in all cases reflect the collection efforts in a particular area. Future study and collection will surely extend the following list of localities in which medusae have been found.

Discussion

This combination of the old and new records presents an interesting pattern on the map of Indiana. The 13 new records extend the known range of *Craspedacusta* across south central Indiana in a narrow belt and expand it in the northern lake district. There are at present no records for the wide strip separating these two areas, and there is a single record for the southernmost quarter of the state.

What this pattern seems to indicate is that more extensive collecting may reveal jellyfish throughout most of Indiana, particularly in the southern portion and perhaps in the north central portion, but the latter remains doubtful. Also, the large number of impoundments recently constructed in many areas of the state may prove important for the freshwater jellyfish by providing many new habitats for the species.

It is interesting to note the types of habitat in which medusae have appeared in Indiana. Of the total of 17 records, six have been in

NEW INDIANA RECORDS

Location	County	Dates	Collectors
1. Heaton Lake	Elkhart	1951	Indiana Lake & Stream Survey
2. Diamond Lake	Noble	1952	Indiana Lake & Stream Survey
3. Syracuse Lake	Kosciusko	late 20's or early 30's	Payne
4. Winona Lake	Kosciusko	late 20's or early 30's	Payne
5. Myers Lake	Marshall	1952-55; 1957	Eberly, Lytle
6. Beanblossom Reservoir	Monroe	1955	Breneman
7. Jones Lake (artificial)	Monroe	1953; 1957	Crowell, Lytle, Barker
8. three flooded	Monroe	1948-1957	Crowell, Lytle
9. limestone	"		
10. quarries	"		
11. Yellowwood Lake (artificial)	Brown	1951-3; 1956-7	Frey
12. Ault Lake (artificial)	Brown	1953	Crowell, Owen
13 Stony Point Quarry	Clark	1957	Smith

artificial lakes, six in quarries or gravel pits, and five in natural lakes. The occurrences in natural lakes are of particular interest because there are relatively few reports of medusae in natural lakes in other parts of the country.

Another interesting feature of these medusae is the time of their appearance. Continuous observations throughout a summer have been made only rarely, so the information on the persistence of medusae populations is sketchy. However, the available data do indicate that populations in northern lakes appear later and disappear sooner than those in the southern half of the state. Medusae are generally present between July and October in south central Indiana and in August and September in northern counties. They have been observed as early as July 6 and as late as November 9 in Monroe County. The appearance and disappearance of the medusae appear to be linked with the temperature of the surface waters of the lake or pond, but as the recent work of Pennak (8) has shown, this relationship is not a simple one.

The problem of sex in these animals is a puzzling one. Although only a few medusa populations have been studied extensively, in almost every case the medusae have been either all male or all female. Only three times in the United States have both sexes been found in the same habitat. In Indiana we have studied a limited number of specimens from seven locations and have found only females. Various attempts have been made to explain this monosexual phenomenon on the basis of an ecological sex determination or on the basis of clones derived through budding from a single polyp, but the question of sex still remains unanswered.

One word should be added about the polyp generation. The hydroids of this species are very small, inconspicuous and difficult to collect. So far they have been collected in only three habitats in this state: Boss Lake, Myers Lake, and Red Dog Quarry, near Bloomington. Their presence in the other habitats is almost certain, for it is a particular series of events in the life of the polyp generation which determines the formation of medusae.

Summary

Freshwater medusae have occurred in thirteen new localities ir Indiana, presenting a discontinuous pattern of distribution extending to all four borders of the state. The medusae were observed most commonly in artificial habitats, as limestone quarries, gravel pits, and artificial lakes. Five occurrences have been in natural lakes in the northern lake district. Specimens examined from seven locations were all female. Medusae were usually present between July and October in south central Indiana and in August and September in northern counties.

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The Effect of Stilbestrol on the Ovary of the Immature White Leghorn Pullet[1]

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The past few years have witnessed the unfolding of a new concept in the field of endocrinology. This idea is that a hormone may have an effect on the gland which secretes it. Estrogens, a group of hormones from the ovary, have been known for many years to affect the secondary sex characteristics of the female animal. Recent experimentation, chiefly on mammals, has shown that the estrogens may also act directly on the ovary. This was suggested by Bradbury (1) who noted that there was an increase in ovarian weight when estrogen was given to immature female rats. Estradiol-benzoate, when given to hypophysectomized rats, was shown by de Wit (2) to stimulate mitosis in the granulosa cells and also to produce cell enlargement. The effect of stilbestrol, a synthetic estrogen, on the ovary of the immature hypophysectomized rat appeared to be true stimulation as it was characterized by an abundant production of medium sized follicles, Payne and Hellbaum (3). These authors also noted a direct relationship between dosage and ovarian weight. The purpose of this paper is to present some information regarding the effect of large doses of stilbestrol on the ovary of the immature pullet.

Materials and Methods: The experimental animals used in this investigation were Single-Comb White Leghorn pullets. Stilbestrol was suspended in sesame oil, which, accordingly, was also injected into the control birds. The stilbestrol and sesame oil were administered subcutaneously and concentrations were made up so that each bird received 0.1 c.c. of the oil daily. In this particular study stilbestrol, in amounts of 2.0 mg., 4.0 mg., and 8.0 mg., was injected into pullets starting at 20 days of age and continuing for 8 and 12 days. Twenty-four hours after the last injection the birds were killed by decapitation, the desired glands were quickly removed and were placed in Bouin's fixing solution. The tissues were stained in the usual manner with Harris' haemotoxylin and eosin.

Results: The stilbestrol caused significant decreases in comb weights and significant increases in oviduct weights for both age groups of birds. The ovarian weights (Table I) were not changed significantly although in the older birds the ovarian weights were slightly lower than those observed in the controls. To further study the possible action on the ovary by stilbestrol, the diameters of ovarian follicles were measured. The results are presented in Table I and they indicate

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[1] Contribution No. 652 from the Zoology Department, Indiana University.

[2] This study is based on one section of a dissertation by the author to The Faculty of the Graduate School of Arts and Sciences of Indiana University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

TABLE I

Effects of Stilbestrol on the Ovary

Series	Total Treatment	Ovary Weight[1]	Follicular Area
Series 1-4	Injected 8 days:	(20 to 28 days of age)	
1	Controls—oil	30.2 ± 6.4[2]	19,010 ± 9,000
2	2.0 mg. Stil.	30.5 ± 12.8	33,340 ± 6,920
3	4.0 mg. Stil.	27.1 ± 6.1	35,999 ± 6,480*[3]
4	8.0 mg. Stil.	30.6 ± 8.4	30,730 ± 5,670
Series 5-8	Injected 12 days:	(20 to 32 days of age)	
5	Controls—oil	34.7 ± 6.0	31,000 ± 7,880
6	2.0 mg. Stil.	34.2 ± 6.0	35,274 ± 10,720
7	4.0 mg. Stil.	33.2 ± 6.4	35,800 ± 10,140
8	8.0 mg. Stil.	32.6 ± 9.0	54,000 ± 11,120*[3]
Series 9-12	Injected 8 days:	(32 to 40 days of age)	
9	Controls—oil	26.4 ± 3.0	68,903 ± 13,600
10	2.0 mg. Stil.	29.7 ± 3.1	88,802 ± 18,200
11	20 IU PMS	30.9 ± 4.9	102,814 ± 11,900
12	2.0 mg. Stil. + 20 IU PMS	27.1 ± 6.4	83,375 ± 16,000

[1] All values expressed as milligrams per cent body weight.

[2] Standard deviation

[3] Significant at the 5.0% level

that stilbestrol treated birds have larger ovarian follicles than do the ovaries of normal control birds of the same age. Thus, even though the effect on ovarian weight was negligible, all dosage levels of stilbestrol appeared to have a stimulatory effect on the follicles. Series 3 and 8 show an increase in average follicular size which is statistically significant at the 5% level by the "t" test.

The question arises as to whether or not this follicular stimulation by stilbestrol is direct or indirect; that is, does the stilbestrol make the follicle more sensitive to gonadotrophic action or does it act directly on the follicle? This was tested by administering to 32-day-old pullets a total dosage of 2.0 mg. stilbestrol and 20.0 International Units of the gonadotrophic substance pregnant mare serum (PMS) separately and in combination over a period of 8 days. The results are shown in the last three lines of Table I. The hormones, alone and in combination, all slightly augmented ovarian weights. The birds which received the hormones in combination developed larger follicles than did the controls but follicle size was somewhat smaller than those in the birds which were given the hormones alone. This would seem to indicate that stilbestrol does not make the follicle more sensitive to gonadotrophin—at least to exogenous gonadotrophin.

Summary

Large doses of stilbestrol, a synthetic estrogen, were given to immature White Leghorn pullets. Although there was little effect on ovarian weight, the average diameter of ovarian follicles of the treated birds was larger than the follicle diameters of the control birds. Pregnant mare serum, a gonadotrophic substance, also increased follicular size but this action was not augmented by stilbestrol. These results would indicate that stilbestrol does act directly on the ovary of the immature pullet.

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The Action of Lithosperm[1] in Mice

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Interest in the anti-gonadal effects of the plant *Lithospermum ruderale* was stimulated by the initial experiments of Cranston (1), Drasher and Zahl (3), and Drasher (2). These investigators demonstrated that the feeding of dried overground parts of the plant inhibited the estrus cycles of mice and that the animals usually lapsed into extended periods of diestrus. It was necessary in these experiments, however, to feed the plant material in considerable quantity, approximately 30% of the diet. Treatment was often accompanied by weight losses which complicated the interpretation of the results since it was suggested that the observed diestrus might be a result of poor nutrition. Extracts of the plant were not effective since they rapidly lost activity and frequently were toxic. Consequently, Drasher (2), Noble et al. (4), and others attempted to extract the active principle from the plant and to produce a stable preparation. These attempts were not very successful but their work clarified certain phases of the problem: namely, that lithosperm actually was anti-gonadal in its action and that it probably inactivated anterior pituitary hormone LH, the luteinizing hormone.

Materials and Methods

Female white Swiss mice approximately 2½ months of age were used in these experiments. Five animals were kept in each cage in air-conditioned animal quarters. Each animal was ear-marked and vaginal smears were taken by the lavage method for from 12 to 14 days before the beginning of the experiment. Vaginal smears were stained mith aqueous-methylene blue and allowed to air-dry after which they were read. We were thus able to establish the cycle of each mouse and to allot experimental animals to groups according to the reproductive cycles which were demonstrated during the pre-treatment period.

The animals were treated with the lithosperm preparation in two ways: they were injected subcutaneously with 0.1 ml. daily, or were given the lithosperm orally also in 0.1 ml. daily. The control animals were administered distilled water orally or subcutaneously. An apparatus comparable with that which is sometimes used for oral administration of drugs to rats was used for feeding lithosperm to the mice. A small piece of polyethylene tubing with an outside diameter of 0.060 inches was slipped over the end of a long 22 gauge injection needle. The needle was attached to a 1 ml. tuberculin syringe graduated in 0.01 ml. so that accurate amounts of preparation could be administered. Paraffin was placed about the junction of the polyethylene tubing and the needle in order to avoid loss of fluid by back pressure. The mouth of the mouse was kept open by hooking the incisor teeth over a V-shaped mounting bar and the polyethylene tube was then inserted into the stomach. If the tongue is placed below the lower bar the insertion of the tube into the esophagus and stomach can be made without difficulty.

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[1] The term lithosperm is used as a generic designation for the hormone inhibiting principle, or principles, present in the genus *Lithospermum*.

[2] Contribution number 653 of the Zoology Department and number 819 of the Chemistry Department of Indiana University.

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The lithosperm preparation used in this study was a spray-dried powder which was made from a cold water extract of dried, ground plant material. We are indebted to the Smith, Kline and French Laboratories for the preparation of this material. The spray-dried powder has been used in numerous experiments in this laboratory and has remained stable and active for more than a year. The powder was mixed with distilled water before administration and the dosages used were on the basis of milligrams of powder per milliliter of solution.

Results and Discussion

Since all of the animals used in the experiments were selected from animals with known estrus cycles determined by pre-treatment obser-

TABLE 1

Effect of Lithosperm on the Estrus Cycle of Mice

Amount of Lithosperm and method of administration	Amount of Estrus smears observed	% expected	No. of Metestrus I Smears observed	% expected	Totals	% expected
0.4 mg/0.1 ml. subcutaneously	30	88	19	119	49	98
0.4 mg./0.1 ml. tube fed	20	54	9	69	29	58
0.6 mg./0.1 ml. subcutaneously	31	79	13	81	44	80
0.6 mg./0.1 ml. tube fed	13	39	15	125	28	62
0.8 mg./0.1 ml. subcutaneously	22	69	16	55	38	62
0.8 mg./0.1 ml. tube fed	23	56	6	46	29	54
1.0 mg./0.1 ml. subcutaneously	26	42	11	23	37	34
1.0 mg./0.1 ml. tube fed	30	44	16	36	46	41
Totals	195		105			
% Expected		56		55		

vations of smears, it was possible to estimate how many periods of estrus would be expected to occur during the 20 day treatment period if lithosperm were not effective. A slight change in the usual procedure of evaluating the cycles was employed. It was felt that a more accurate picture of cycles would be obtained if metestrus I stages as well as estrus stages were counted because it might be possible to miss estrus stages from time to time. Table I presents the results of the experiments in which lithosperm was administered both by subcutaneous injection and by tube feeding.

The data clearly demonstrate several important points relative to the action of the spray-dried lithosperm preparation in mice. The administration of the plant extract by feeding was more effective than by subcutaneous injection. Even the lowest dosage of 0.4 mg. per day had slight inhibitory effect. The highest dosage, 1.0 mg. per day, was the only one in which the subcutaneous treatment appeared to be slightly more effective. The totals on the right of the table illustrate these differences in response according to the route of administration and likewise demonstrate that there is an increase in inhibition of the estrus cycles as the dosage of lithosperm is increased.

It is also of interest to note the results represented by the totals of vertical columns. The percentage of inhibition as indicated by the number of estrus and metestrus I smears is almost identical; 56% compared with 55%. We believe that this supports the idea that the two stages afford an excellent method of characterizing the estrus cycles. It will be recalled that lithosperm constituted as much as 30% of the diet in earlier experiments, but in these experiments dosages of 1.0 mg. per day of the powder and less had inhibitory effect, furthermore, the mice did not lose weight. We believe the inanition is not a complicating factor in these experiments and that very small amounts of the spray-dried preparation are potent.

Since it has been suggested that lithosperm inactivates the luteinizing hormone, or perhaps prevent its secretion, a histological study was made of some of the ovaries of control mice and lithosperm treated mice. All ovaries were removed from the mice when they were in diestrus. The number of corpora lutea in the ovaries were counted and this was correlated with the number of estrus smears which had been observed in these mice. These results are given in Table 2.

There is a clear difference between the number of corpora lutea and the number of estrus smears in the control and treated mice. Only mouse number 53 of the injected mice was comparable with the controls. The 14 ovaries represented in the controls had a total of 35 corpora lutea, whereas there were only 7 corpora in the 16 treated ovaries and 5 of these appeared in mouse number 53. These data support previous suggestions by other workers that the administration of lithosperm prevents the action of the luteinizing hormone. At present, however, the evidence is not adequate to explain whether inactivation of the hormone, prevention of its secretion by the anterior pituitary, or both factors are involved in the mechanism of inactivation.

TABLE 2

Number of Corpora Lutea in the two ovaries of lithosperm treated and control mice

Treatment	Mouse	Corpora Lutea	Estrus Smears
Lithosperm—Daily 1.0 mg./0.1 ml.			
Subcutaneous injection	2	0	0
	12	1	0
	27	0	1
	53	5	5
Tube fed	47	0	2
	1	0	0
	15	1	0
	30	0	0
Controls	14	3	0
	35	9	3
	46	3	1
	60	5	2
	28	2	3
	41	5	3
	55	8	2

Summary

Administration of a spray-dried preparation of *Lithospermum ruderale* (lithosperm) by subcutaneous injection or by tube feeding inhibited the estrus cycles of mice. Tube feeding was more efficacious than was subcutaneous administration and as little as 0.4 mg. of powder per day had a demonstrable effect. The number of corpora lutea in the ovaries also was significantly fewer in the lithosperm treated mice than in the controls.

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Some Observations on a Summer Colony of *Myotis Lucifugus*

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The use of numbered bands as an aid in studying the natural history of bats was initiated in 1916 by Allen (1), who banded 4 *Pipistrellus*. Since this small beginning many investigators in Europe and America have used this method in studying the life histories and behavior of bats.

Cope and Mumford (4) gave a summary of bat banding in Indiana through July 1954, at which time 6,400 bats had been banded in the state. Since that time the authors have continued their activities and over twice that many have been banded to date. Interest in compiling data concerning the range, populations, and seasonal distribution of all species of Indiana bats continues. However, incidental to these aims, other data have been obtained which seem appropriate to bring to the Academy at this time.

It has been demonstrated by several investigators that bats have a well-developed homing instinct (3, 8, 9, 10). The aim in this paper is to report to the Academy the work that has been done thus far on a summer colony of *Myotis lucifugus* in Indiana, with the hope of obtaining cooperation in locating additional summer colonies in the future. This type of information would greatly facilitate the investigation.

Banding

A large *Myotis lucifugus* breeding colony was located by Mumford in August 1954, at Tunnelton, Lawrence County, Indiana. He banded 156 females and 73 males. None of these was aged, as it is difficult to determine immatures at that time of the year. They were taken to West Terre Haute, Indiana (77 air miles northwest of Tunnelton) and released the same night. The colony was checked again by Cope and Mumford on October 1, 1954. They banded 28 females and 151 males and released them at Bedford, 10 miles northwest, the same day.

In the spring of 1955, Mumford and Ralph D. Kirkpatrick banded 278 females and 5 males, liberating them 2 miles south of the colony. The colony was not visited again until July 4, 1956, when Cope and Wilson banded 302 individuals. Wilson took 52 adult males, 14 adult females, and 15 subadults of both sexes and released them at Bardstown, Kentucky, 82 air miles southeast of Tunnelton, the next day. Cope took 141 adult males, 40 adult females and 40 subadults of both sexes and liberated them in Richmond, Indiana, 107 air miles northeast of the point of capture. Cope and Wilson returned to the colony that fall, banded 44 males and 2 females, and liberated them at Spring Mill State Park, 4 air miles southwest of Tunnelton. On July 4, 1957, Cope and Wilson banded 364 (281 adult females, 16 adult males, and 67 subadults of both sexes). Of these 118 adults were liberated in West Lafayette, 120 air miles northwest; 120 adults and 13 subadults were liberated in

Crawfordsville, 93 air miles northwest; 59 adults were liberated in Greencastle, 66 air miles northwest; and 54 subadults were released south of Buddha, 4 miles northwest of Tunnelton. On August 7, 1957, Mumford and Wilson banded 371 (258 females and 113 males) which were all released at Spring Mill State Park, 4 air miles southwest of Tunnelton. The total number of bats banded to date in the colony is 1,774 (1,196 adult females, 65 subadult females, 456 adult males, and 57 subadult males).

An analysis of Table I gives several clues as to what is happening at the Tunnelton colony. The first thing that becomes evident is that there is a shift in the sex ratio between the first and last part of the season. The two October dates indicate a high percentage of males, while the spring and summer counts indicate a high percentage of females. Although it was impossible to capture all of the bats on any one visit, a concerted effort was made to collect all of the banded ones. It is probable that about the same number of individuals escaped capture each trip. Thus, the difference cannot be correlated with the ease of capture of one sex over the other at the various seasons. We feel that the observed disparity in the sex ratio is real.

The males in the Tunnelton colony exhibited a different pattern of behavior from that suggested by other workers. Griffin (6) states of summer colonies of *Myotis lucifugus* in New England, "on rare occasions an adult male may be taken, usually very early or late in the summer". Cagle and Cockrum (2), working in Illinois, say, "a few adult males were always present in the colony but the majority of them did not return until the first week of June". Eisentraut (5) states that in the European species *(Myotis myotis)* "the sexes are promiscuously mixed in winter quarters, but the males and females are separated for at least the first half of the warm season".

In the colony under discussion, we found that 98 percent of the animals caught April 20 were females. Two collections made in July were composed of 78 and 95 percent females, respectively. One late August visit revealed that still over half (68 per cent) of the colony was made up of females. By the first of October the picture had changed and 84 per cent were males. By the second week of October, most of the bats had left, but males comprised 96 per cent of the bats captured.

It seems that this colony is used in late spring and most of the summer as a nursery ward, but serves as a male roosting colony in late summer and early fall. This might be evidence of a congregation roost for males, before they go into the caves for the winter. There are a number of caves within a few miles of the Tunnelton site.

Homing

The homing ability of the Tunnelton bats is not outstanding, but does show that regardless of the direction in which liberated, a small per cent return. Smith and Hale (11) report 2 *Myotis lucifugus* which returned after being released at a distance of 228 air miles. The greatest distance from which bats have returned to Tunnelton is 120 air miles. This was a group released at West Lafayette, from which 20 per cent

TABLE 1

Banding, Release Point and Return of a Colony of *Myotis lucifugus* from Tunnelton, Indiana

Place Liberated	Air Miles from Colony	Number Banded					Percent Return					
		adult female	adult male	s ad. female	s ad. male	Total	10-1-54	4-20-55	7-4-56	10-7-56	7-4-57	8-7-57
1. 8-30-54 W. Terre Haute	77	156	73			229	.05	.03	.03	.007	.08	12
2. 10-1-54 Bedford	10	28	151			179		.02	.08	.01	.04	.05
3. 4-20-55 S. of Tunnelton	2	278	5			283			.09	0	.18	22
4. 7-4-56 Bardstown, Ky.	82	52	14			66				.03	.12	23
"				13	2	15				0	0	0
5. 7-4-56 Richmond	107	141	40			181				.01	.09	13
"				20	20	40				0	0	0

6. 10-7-56 Spring Mill	4	2	44			46	.17	18
7. 7-4-57 W. Lafayette	120	110	8			118		21
8. 7-4-57 Crawfordsville	93	120			13	133		18
9. 7-4-57 Greencastle	66	51	8			59		31
10. 7-4-57 S. of Buddha	4			32	22	54		.07
11. 8-7-57 Spring Mill	4	258	113			371		
Total		1196	456	65	57	1774		

of the females and 25 per cent of the males homed successfully, when checked 34 days later.

Griffin (7) observed that *Myotis lucifugus* liberated near the roost had a lower per cent return than those released at a greater distance. Hitchock and Reynolds (9) have also observed this. Smith (10) working in north central Ohio found that 14.3 per cent of the bats liberated at the place of capture returned, and only 6.5 per cent returned when released 49 miles from the point of capture.

In analyzing our data, it is apparent that we cannot substantiate what these workers have found with regard to the frequency of return from greater or shorter distances. The highest per cent return (31) was from a release point 66 miles from the point of capture. There were 5 release sites at greater distances (120, 107, 93, 82, and 77 miles). The smallest percentage of return, excluding subadults, was 0.05, from a distance of 10 miles. There were 3 release locations with shorter distances (4, 4, and 2 miles). From the shortest distance, 22 per cent returned.

Summer and Winter Locations

We have captured in the Tunnelton colony, 5 little brown bats which were banded in caves in winter. It is interesting to note that the distances traveled by these animals are not great, varying from 8 to 37 miles. Three had been banded northwest of the colony and two had been banded southeast of it. It is interesting to us that individuals from a wintering colony should become a part of a different colony during the summer, as these five records indicate. This seems to indicate a general break-up and dispersion of winter colonies in the spring, and of summer colonies in the fall.

Summary

A colony of *Myotis lucifugus* in southern Indiana has been studied for the last three years with a total of 1,774 bats banded.

Visits to the colony at different times of the summer indicate a shift from a predominate female population from April to September to a predominately male population in October.

Homing experiments have been conducted and from the greatest distance (120 air miles) from point of capture, 21 per cent returned 34 days later.

There are five winter banding records which give an indication of wintering-summering range. The greatest distance from winter cave to summer colony was 37 miles, the shortest, 8 miles. They were from a northwest and a southeast direction.

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Two Representatives of a Tropical Suborder of Opilionids (Arachnida) Found in Indiana[1]

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The arachnid order Opiliones is divided into three suborders; all three of these orders are found in the United States, but only one is common. This common group is the suborder Palpatores, which is represented here by the ubiquitous, long-legged, "daddy-long-legs" or harvestmen. Another suborder, Laniatores, is less familiar. Most of its members have flattened bodies and short legs. The third suborder, Cypophthalmi, consists of small, secretive forms which are found in only a few areas such as Florida, Washington, and Oregon.

While the members of the suborder Palpatores are found throughout the tropical, subtropical, and temperate sections of the world, the Laniatores are confined chiefly to the tropical and subtropical areas. In such regions, these forms are often very abundant and highly varied in appearance. Some have elaborate white patterns upon their backs with varying arrangements of spines and tubercles. Only a few forms are found as far north as the United States; however, two species are found abundantly in a few localities in Indiana. These two species are *Vonones ornata* (Wood) and *Phalangodes flavescens* (Cope).

Vonones ornata belongs to the family Cosmetidae. It has a flattened reddish body with some white markings and short legs. The body is about five millimeters long, and the legs vary in length from eight to 15 millimeters. *Vonones ornata* is widely distributed through southern Indiana. One of the northernmost populations is along the Wabash River just south of Lafayette.

During the summer these animals are found under rotting logs and usually occur singly or in pairs, rarely are they found in large numbers in any one place. As fall approaches, they begin to aggregate in large groups, often numbering up to 50 individuals under a single brush heap or pile of logs. At the approach of cold weather, they apparently disappear into the ground and are not found again until spring. From our observations, it appears that many are able to survive the winter by lodging in protected spots. In the spring and early summer, both adults and immature forms are found.

From cytological studies, it appears that they must breed throughout the summer months, and then lay the eggs under the logs or in the leaf mold.

In making studies of collections, it was noted several times that the females outnumbered the males in a ratio of nearly two to one. This is difficult to understand, for the spermatogenesis in the male followed the usual pattern and should have resulted in the normal one to one ratio of sexes.

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[1] This study represents a portion of an investigation supported by a grant from the National Science Foundation.

Their food seems to consist chiefly of smaller invertebrates and debris. In captivity, they have been observed to feed upon small pieces of liver and ground beef.

Phalangodes flavescens has been found in only one locality in Indiana, Wyandotte Cave. This is the type locality of this species, but it has been found in a few sections of Ohio, Virginia, West Virginia, and other southeastern states. This is a very small reddish form with its body averaging about two millimeters in length, and the legs between four and six millimeters. It is a member of the family Phalangodidae, the members of which are found throughout the tropical and subtropical areas of the world.

In Wyandotte Cave, this species was found in great abundance among rotting pieces of wood which had been carried into the cave. Here it appeared to be feeding upon the fungus which covered the wood. This species can not be regarded as a strictly cave form, for it has not lost its eyes and does not have extremely long legs. Also, it is very commonly found outside caves.

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The selection of papers for the Proceedings is the responsibility of the Editorial Committee.

INDEX

Action of lithosperm in mice, 312.
Adams, W. R., 90.
Age pyramids for Indiana's Counties and larger cities, 187.
Agglutination reactions, effect of formaldehyde on red cell, 98.
Aggression and avoidance in the C57BL mouse, 298.
Aging of reagent solutions in precipitation processes, 128.
Alpha particle irradiation of germanium at 4.2°k, 278.
Annual rings, relation of, to multiple flushes of growth in several species of *Quercus,* 104.
Anthophilous insects of Indiana, 160.
Anthropology division, 90.
Axenic cultivation of planarians, 301.

Babcock, R. F., 128.
Bacteriological problems in food, 99.
Bacteriology division, 98.
Barium sulfate, effect of age of reagent solutions on particle size of, 128.
Barton, Jay II, 301.
Basidiomycete which sporulates in artificial culture, 107.
Beals, H. O., 103.
Bee, alkali, 135.
Belinfante, F. J., 280.
Bell, W., 298.
Belohlov, L. R., 109.
Bentley, A. F., memorial, 56.
Berka, C. A., 303.
Bertrand, A. R., 232, 233.
Beta decay of Ru^{103}, 281.
Biebel, P., 102.
Bieber, C. L., 185.
Blanchard, R. E., 297.
Blasingham, E. J., 90.
Botany division, 101.
Bray, R., 281.
Breneman, W. R., 312.
Brumbaugh, J. H., 301.
Brumfiel, C., 274.
Buried forests in Indiana, 103.
Burr, I., 274.
Bybee, H. P., memorial, 58.

Campaigne, E., 109.
Canright, J. E., 268.
Carmack, M., 312.
Cave planarians, preliminary studies on pigmentation in, 300.
Cephalopods, Mississippian of Putnam Co., 185.
Characterization of N–adic equivalence relations, 274.
Clark, J. A., 6, 7.
Class administration in courses using a textbook, 274.
Cleland, R. E., 8, 17.
Coats, N. M., 7, 14.
Coleoptera-Caraidae, prey records of ground beetles, 136.
Conklin, R. L., 280.
Contributions to the flora of Wayne County, III, 290.
Coordination complexes, calculation of formation constants using computers, 111.
Cope, J. B., 316.
Corn borer, location of larvae of the European, *Pyrausta nubilalis,* in dent corn, 155.
Correll, M., 277.
Costas, P., 199.
Cross, E. A., 135.
Crull, H. E., 6, 7, 9, 16, 18.
Culiseta melanura, occurrence of, in Indiana, 137.
Cunningham, R. W., 281.
Cyclic sedimentation, 205.

Daily, F., 101.
Daily, W. A., 6, 7.
Daniels, R. P., 107.
Davis, J. J., 135.
Davis, R. C., 298.
Deay, H. O., 135.
DeLanney, L. E., 302.
Denenberg, V. H., 298.
DenUyl, D., 243, 244.
Development of the spleen of *Taricha torosa* and its experimental modification, 302.
Differences between normals and psychotics in the perception of serially diffused visual stimuli, 299.
Diptera, a list of species collected from blossoms, 160.
Divisional chairmen, 6.
Drainage in Indiana and soil use, 249.
Driver, H. E., 90.

Drosophilidae found in tomato fields in Indiana, 138.
Duncan, W. G., 232, 234.

Ecological correlations in Indiana, some, 101.
Ecological sampling methods for trees, comparison of, 101.
Edington, W. E., 56.
Edwards, P. D., 274.
Effect of decrease in size of reward on runway latency scores in the hooded rat, 297.
Effect of formaldehyde on the agglutination of red cells by antiserum against artifically attached antigens, 98.
Effect of hue, brightness and saturation on color preference, considering various contexts, 297.
Electric light traps and their uses in entomology, 135.
Electric computers, applications to chemical computations, 111, 117.
Entomology division, 135.
European corn borer, *Pyrausta nubilalis* (Hbn.), location of larva in dent corn, 155.
Everly, R. T., 136.
Evidence of introgressive hybridization and mutation in certain Colorado populations of *Aquilegia,* 292.
Executive committee, 6.
Experimental comparison of A-C powered diode and hydrogen ion gauge circuits for leak detection in a high vacuum system, 277.
Extent of effectiveness of natural selection, 251.

Factors affecting the toxicity of sodium pentachlorophenate to fish, 303.
Fan, H. Y., 279.
Farquharson, L. I., 102.
Favinger, J., 135.
Fischbeck, H., 278.
Fischer, R. B., 109, 128.
Fish, toxicity to, 303.
Food, bacteriological problems in, 99.
Forests, buried, of Indiana, 103.
Forests of the lower Wabash Bottomlands during the period 1870-1890, 244.
Formation of annual rings, relation of, to multiple flushes in several species of *Quercus,* 104.
Fossil cephalopods of Mississippian age, central Putnam County, Indiana, 185.
Free radical additions, some, to perfluoro-1-heptene, 109.
Fuller, W. R., 275.

Galloway, J. J., 175.
Garofolo, L., 298.
Gastrointestinal activity in hunger and after food, the question of hunger pangs, 298.
Geologic observations on Southhampton Island, 176.
Geology and geography division, 175.
Gerritsen, A. N., 280.
Girton, R. E., 260.
Glacial period, Indiana's climate during, 183.
Gobeli, G. W., 278.
Goniatites, western Indiana, 185.
Goodnight, C. J., 322.
Gopher, 303.
Gould, G. E., 136.
Graves, G. H., 274.
Grollig, F. X., 92.
Guard, A. T., 104, 286.
Guernsey, L., 215.
Gunther, W. C., 303.

Hall, M., 286.
Hamilton, J. H., 280.
Harrison, E. F., 99.
Hart, John Fraser, 175, 187.
Heats of combustion, a method of calculating, of organic compounds, 122.
Helianthus, natural hybrids, 286.
Hershman, J. B., memorial, 59.
High-speed calculation of least-squares best
  consecutive formation constants of metal-ion complexes using an electronic computer, 111.
  half-wave potentials and slopes of polarographic waves using an electronic computer, 117.
History of
  early development of game regulations in Indiana, 256.
  Indiana moss studies, 243.
  science division, 243.
Homologies in the male reproductive system of the California pocket gopher (*Thomomys bottae navus* Merriam), 303.
Hopp, W., 300.
Hoskins, J. H., memorial, 61.
Howe, R. H. L., 277.
Hsu, C. G., 109.
Hummel, A. D., 275.
Hunt, H., 122.
Huston, H. H., memorial, 62.
Hybrid population, study of a natural, among three species of *Tragopogon,* 286.

Indians, prehistoric, 90.
Industrial mineral resources of Washington County, Indiana, 177.

Industrial minerals in Indiana's economy, 177.
Influence of nitrogen and clippings on the roots of two grasses, 233.
Information handling and numerical control, 279.
Ingraham, J. S., 98.
Insect abundance in Indiana in 1957, 150.
Insect pests, some new, of trees and shrubs of Indiana, 145.
Insects and other arthropods of economic importance in Indiana in 1957, 150.
Inter-relationship of applications and mathematical research, 276.
Interurban distance in Indiana; an evaluation of techniques, 199.
Introgressive hybridization, 292.
Irrigation in Indiana, 249.

Jamieson, W. A., memorial, 64.
Japanese beetle infestation in Newton County, 136.
Japanese beetle in Indiana, notes on distribution of, 136.
Johnson, Jr., J. I., 298.
Johnson, W. H., 6, 7, 73, 301.
Johnston, R. B., 96.
Jump, J. A., 101.
Junior Academy—council members, exhibits, minutes, officers and program, 49.

Karas, G. G., 297.
Kennedy, R. J., 109.
Killing action, a new type of, in a stock of *Paramecium aurelia* from Panama, 303.
King, L. J., 287.
Konetzka, W., 98.
Kraybill, H. R., memorial, 66.

Laff, R. A., 279.
Langston, R. G., 232.
Large aggregation of larvel millipeds, *Zinaria butleri* (McNeill), in Brown County, Indiana, 171.
Lark-Horovitz, K., 278.
Laubengayer, R. A., 6, 7, 11.
Lawrence, J. L., 274.
Lehker, G. E., 173.
Lewis, G. W., 297.
Life in Indiana during the glacial period, 183.
Lifetime, minority carrier, in indium antimonide, 179.
Light traps, 135.
Limestone, specific surface and reaction rate of calcitric, in neutralizing soil acidity, 237.
Lindsey, A. A., 101.
List of the pteridophytes and monocotyledonous species in Wayne County, Indiana, 290.
Lithosperm, the action of, on mice, 312.
Localization experiment for teaching geometry, 275.
Lorentz-Covariance of commutation relations, 280.
Lounsbury, R. W., 225.
Lovell, C. W., Jr., 232.
Lovell, G., 297.
Luginbill, P., memorial, 68.
Luminescence excited by vacuum ultraviolet radiation, 280.
Lytle, C. F., 304.

Madinger, F. L., 136.
Magnetic fields in the solar atmosphere, 277.
Markle, C. A., 12, 190.
Martin, F. P., 90.
Martin, H. J., 279
Martin, W. C., 286.
Mathematics division, 274.
Mathematics of the future, 274.
McBee, E. T., 109.
McCormick, E. J., 297.
McCoy, S., 7.
McGregor, D. J., 177.
McMasters, D. L., 111, 117.
Measurement, absolute, of beta-activities using sources of saturation thickness, 278.
Measurement and shapes of beta spectra, 280.
Melhorn, W. N., 194.
Membership list, 19.
Memorials,
    Bentley, A. F., 56.
    Bybee, H. P., 58.
    Hershman, J. B., 59.
    Hoskins, J. H., 61.
    Huston, H. A., 62.
    Jamieson, W. A., 64.
    Kraybill, H. R., 66.
    Luginbill, P., 68.
    O'Grady, D. C., 69.
    Stantz, G., 70.
    Welte, Sister C., 71.
Method of calculating the heats of combustion of organic compounds, 122.
Methods of sampling in forest ecology, 101.
Michaud, H. H., 7, 243, 256.
Michels, K. M., 297.
Miles, S. R., 101.
Miller, C. A., 301.
Millipeds, aggregation of, 171.
Mississippian-Devonian Boundary, revision in White and Benton Counties, Indiana, 194.

Moffat, A., 122.
Montgomery, B. E., 160.
Morgan, W. P., 7, 11.
Morris, C. S., 282.
Mosing, L. W., 299.
Moss studies, history of Indiana, 243.
Motto, H., 237.
Mounds, archaeological excavation of prehistoric Indian, 96.
Mullin, C. A., 155.
Mumford, R. E., 316.
Murray, H. H., 205.
Murray, H. L., 99.

Natural hybridization in *Helianthus,* 286.
Nature of variations, 251.
Necrology, 56.
Nelson, T. C., 98.
Netrium, conjugation in, 102.
New type of killing action in a stock of *Paramecium aurelia* from Panama, 302.
Nichols, R. E., 98.
Nielsen, K. L., 276.
Notes on artificially induced nesting of the alkali bee, *Nomia melanderi* Ckll., 135.
Nuclear proteins and genetic information, 301.

Officers of the Academy, 6.
O'Grady, D. C., memorial, 69.
Ohlrogge, A. J., 232, 234.
Opilionids from Indiana, 322.
Optical instruments useful in the bacteriological and biological laboratory, an improved combination, 99.
Orchard soil management, effect of different systems of, on soil moisture and water penetration, 232.
Osmun, J. V., 150.
Oswalt, D. L., 233.
Ottawa in the early historic period, 90.
Ovary, effect of stilbestrol on pullet, 309.
Overmire, T. G., 101.

Paleobotany, history of, in Indiana, 268.
Paleozoic rocks in Indiana, effect of geologic processes on economic resources of state, 178.
Parallelism of cheek skin color in Plethodontid salamanders, 303.
Pelton, J. E., 286.
Pelton, J. S., 292.
Pennsylvanian stratigraphy and sedimentation, 205.
Perfluoro-1-heptene, free radical additions to, 109.
Periodic solutions of nonlinear differential equations, 275.
Perry, T. G., 175, 178.
Pests in Indiana, the ten most important plant feeding, 171.
Petrology of Southampton Island, Northwest Territory, 225.
Physics division, 277.
Physic research in a small institution, 282.
Pigmentation in cave planarians, preliminary studies on, 300.
Planaria, 301.
Plant physiology at Purdue in the nineteenth century, the teaching of, 260.
Plant taxonomy division, 286.
Polarography, calculation of half-way potentials by the method of least-squares, 117.
Pollination, mechanisms of, and seed dispersal in *Lothops,* 101.
Porter, C. L., 107.
Postlethwait, S. N., 104.
Pottery ornaments from Rio Tapajos, Brazil, 92.
Precipitation processes, aging of reagent solutions in, 128.
Preparation of some *w*-trifluoro-aliphatic acids, 109.
Presidential address, 73.
Prey records of ground beetles *(Coleoptera-Carabidae),* 136.
Prickett, P. S., 99.
Psychology division, 297.
Puerckhauer, G. W. R., 109.

Racoons, visual discrimination by, 298.
Radical addition of hydrogen bromide to 2,4,4-Trimethylpentene-2, 109.
Radioactive fall-out, influences on agronomic field experimentation with radioisotopes, 234.
Reactions of diethyl oxalate with ortho-substituted anilines, 109.
Reactions (d,p) in lead, 279.
Reclamation of strip-mined lands in Vigo County, Indiana, 215.
Records of fresh water medusae in Indiana, 304.
Red blood cells, effect of formaldehyde on agglutination of, 98.
Reinforcement, strength of secondary, as a function of the quality of food reward, 297.
Representatives, two, of a tropical suborder of *Opilionids (Arachnida)* found in Indiana, 322.
Reproductive system, male California pocket gopher, 303.
Resistance anomalies in binary alloys at low temperatures, 280.

Reynolds, A. E., 303.
Rice, W. J., 7.
Roberts, C. W., 109.
Robinson, R. L., 281.
Role of entomology in science fair projects, 135.
Ross, A. E., 275.

Salter, L., 277.
Sampling methods, in forest ecology, compared, 101.
Schaal, L. A., 265.
Schaap, W. B., 111, 117.
Schneller, M. V., 302.
Schuder, D. L., 145.
Schultz, R., 15.
Schuster, R. L., 225.
Seed dispersal, and mechanisms of pollination, in *Lithops*, 101.
Sensitivity of *Streptomyces* species to ultra-violet light, 98.
Serpent Mounds Site, Rice Lake, Ontario, the finding after two years of work at, 96.
Shiner, V. J., Jr., 109.
Shrigley, E. W., 98.
Single root fertilization of corn, 232.
Siverly, R. E., 137.
Slope retreat, the misleading antithesis of Penckian and Davisian concepts of, in waning development, 212.
Smith, C. A., Jr., 138.
Smith, D. M., 286.
Smith, M. L., 109.
Smith, R. E., 312.
Soil acidity, specific surface and reaction rate of calcitric limestone in neutralizing, 237.
Soil compaction, some aspects of, 232.
Soil science (affiliate), 232.
Soils of Indiana, their progressively wiser use of, 249.
Specific surface and reaction rate of calcitric limestone in neutralizing soil acidity, 237.
Spleen of *Taricha torosa*, the development of the, and its experimental modification, 302.
Sporulation of *Basidiomycete* in artificial culture, 107.
Stantz, G., memorial, 70.
Strip-mined lands in Vigo County, Indiana, 215.
Stromatoporoid and coral reefs in Indiana, 175.
Summer colony, some observations on, of *Myotis Lucfugis*, 316.
Sunderman, J. A., 177.
Surface integral, the concept of, 274.
Surface investigations in germanium, 281.

Teaching of plant physiology at Purdue in the nineteenth century, 260.
Teel, M. R., 233.
Thompson, H. B., 279.
Tinkle, W. J., 251.
Transgressions and regressions of early Allegheny (Pennsylvania) seas in Indiana, 205.
w-Trifluorotridecanoic acid, preparation of, 109.
Tripsacum-Corn hybrid, 102.
Tuan, Yi-Fu, 212.
Tukey, R. B., 232.
Turner, L. H., 274.

Ultra-violet radiation, sensitivity of *Streptomyces* to, 98.
Undergraduate curricula, 275.

Van Vertha, J. E., 109.
Visher, S. S., 183, 249.

Warrick County, archaeology, 90.
Washington County, industrial minerals of, 177.
Wayne, W. J., 176.
Weather records in Indiana, early, 265.
Weber, G. C., 99.
Weed, on the origin of the term, 287.
Welch, W. H., 7, 15, 243.
Welcher, F. J., 6, 7, 10.
Welte, Sister Carmella, memorial, 71.
White, J. L., 237.
Wife stealing in central Mexico, 90.
Wilkinson, S. R., 234.
Williams, E. C., Jr., 300.
Williams, H. R., Jr., 99.
Wilson, N., 316.
Wright, R. H., 297.

Yuncker, T. G., 7, 8.
Young, F. N., 171.
Youse, H. R., 8.

Zeller, F. J., 309.
Zinaria butleri, 171.
Zoology division, 300.